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U.S. Army Environmental Center

# REMEDIAL INVESTIGATION/FEASIBILITY STUDY
# BADGER ARMY AMMUNITION PLANT
# BARABOO, WISCONSIN

# FINAL
# FEASIBILITY STUDY
## DATA ITEM A009

## VOLUME I OF III
## TEXT

**CONTRACT DAAA15-91-D-0008**
**U.S. ARMY ENVIRONMENTAL CENTER**
**ABERDEEN PROVING GROUND, MARYLAND**

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**AUGUST 1994**

***VOLUME I OF III***
***TEXT***

REMEDIAL INVESTIGATION/FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT
BARABOO, WISCONSIN

# FINAL
# DATA ITEM A009
# FEASIBILITY STUDY REPORT

CONTRACT DAAA15-91-D-0008
TASK ORDER 1

*Prepared for:*

United States Army
Environmental Center
Aberdeen Proving Ground, Maryland

*Prepared by:*

ABB Environmental Services, Inc.
Portland, Maine
Project No. 6853-09

AUGUST 1994

# FINAL FEASIBILITY STUDY
# BADGER ARMY AMMUNITION PLANT

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# EXECUTIVE SUMMARY

This Feasibility Study (FS) report for the Badger Army Ammunition Plant (BAAP) in Baraboo, Wisconsin, was prepared by ABB Environmental Services, Inc. (ABB-ES) as a component of Task Order 1 of Contract DAAA15-91-D-0008 with the U.S. Army Environmental Center (USAEC). This report uses the results presented in the Final Remedial Investigation (RI) report (ABB-ES, 1993a) to develop and screen alternatives for remediation of contaminated media at BAAP.

BAAP has been on standby status since 1977 and there are no plans to schedule the installation for closure. Future land use at BAAP is expected to remain substantially the same as current use which is limited primarily to maintenance of production areas and restricted grazing, farming, and hunting activities.

The FS is being conducted to meet federal permit conditions issued by the U.S. Environmental Protection Agency (USEPA) Region V (USEPA, 1988a), under authority of the Resource Conservation and Recovery Act (RCRA); requirements set forth by the Wisconsin Department of Natural Resources (WDNR) in the In-Field Conditions Report (WDNR, 1987), and modifications to the In-Field Conditions Report (February 1990 and November 1992) under authority of the Wisconsin Environmental Response and Repair Regulations; and Wisconsin solid/hazardous waste regulations (i.e., Wisconsin Administrative Code [WAC] Chapter NR 600). In addition, FS activities were designed and conducted to meet the requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) by USAEC under the National Contingency Plan (NCP) 40 CFR 30. The policies and goals of the National Environmental Policy Act were also considered and incorporated into the FS Report.

The purpose of this FS report is to develop, screen, and evaluate site-specific remedial alternatives to mitigate the impact of site-derived chemicals and ultimately provide protection of human health and the environment. Preferred alternatives for each site are included in this report.

Based on previous environmental studies at BAAP, 11 potential hazardous waste sites were ranked according to potential contributions of hazardous chemicals to the environment. These sites were designated as Waste Management Areas because some of the sites contain multiple Solid Waste Management Units (SWMUs). The sites selected to undergo facility assessment and corrective actions are: (1) the Propellant Burning Ground (including Landfill 1), (2) Deterrent Burning Ground, (3) Existing Landfill, (4) Settling Ponds and

Spoils Disposal Area, (5) Rocket Paste Area, (6) Oleum Plant and Oleum Plant Pond, (7) Nitroglycerine Pond, (8) Old Acid Area, (9) New Acid Area, and (10) Ballistics Pond. The USAEC added an 11th site, the Old Fuel Oil Tank, to the list in October 1989 after discovery of fuel-contaminated soils during excavation of a water line in the vicinity of the old fuel oil tank foundation.

Although designated as Waste Management Areas containing one or more SWMUs, the 11 sites at BAAP are being investigated in the RI/FS process under the U.S. Army Installation Restoration Program. The RI/FS follows CERCLA guidance and is designed to comply with requirements for the RCRA Facility Investigation and Corrective Measures Study.

After reviewing both the contamination assessment and the risk assessment conclusions from the RI Report, the Army divided the 11 Waste Management Areas into two categories: (1) those sites where remediation is required because of documented risk to human health and/or the environment; and (2) those sites where remediation is not recommended because the sites were not identified as either a source of contamination to groundwater or a source of human health and environmental risks. These latter sites are the subject of a separate Decision Document prepared by ABB-ES.

The five sites requiring remedial action are (1) the Propellant Burning Ground, (2) the Deterrent Burning Ground, (3) the Rocket Paste Area, (4) the Nitroglycerine Pond, and (5) the Settling Ponds and Spoils Disposal Area. Because of their proximity and because they are related hydrogeologically through a common surface drainage system, the Rocket Paste Area and Nitroglycerine Pond are combined as one site and referred to as the Nitroglycerine Pond and Rocket Paste Area (NG/RPA) throughout this report. The eventual selected remedies for the investigated sites will be documented in a future modification to the Joint Permit issued by USEPA to BAAP. Final selected remedial measures will be contingent upon input from the general public.

The six sites where the Army does not recommend remedial action are (1) the Existing Landfill, (2) the Oleum Plant and Oleum Plant Pond, (3) the Old Acid Area, (4) the New Acid Area, (5) the Ballistics Pond, and (6) the Old Fuel Oil Tank. ABB-ES prepared a separate Decision Document (ABB-ES, 1993b) explaining the rationale for no-action recommendations at these sites. The Decision Document provides histories of the sites, presents results of environmental investigations at the sites, and explains why no further action will be taken. These six sites are not addressed further in this report other than references to how the geology/hydrogeology of specific sites could affect contaminant transport at a neighboring site requiring remedial action.

The Off-Post Contingency Plan (OCP) (ABB-ES, 1993c) was prepared as a separate document to recommend actions that should be taken if migration of site-related contaminants adversely impacts off-post residential water supplies. The information in the OCP enables a rapid response to protect public health in the unlikely event site-related contaminants should migrate to public and private water supplies from the Propellant Burning Ground in the southern part of BAAP, and from the Deterrent Burning Ground in the northeast part of BAAP.

This FS Report focuses on evaluating appropriate measures to be taken within BAAP boundaries to limit the spread of contamination. In addition, remedial alternatives for long-term solutions at the Off-Post Area south of BAAP are developed in this report.

Development of alternatives to meet remediation goals begins with the identification and screening of potentially applicable remedial technologies. The Remedial Technology Handbook was the primary source of information for remedial technologies identified for each site addressed in this report. Other sources of information included technology literature, vendor information, and FSs prepared by ABB-ES. Site and waste characteristics were considered during the identification process.

The number of identified technologies was reduced during screening in which the advantages and disadvantages of the effectiveness and implementability of each technology were evaluated. Technologies retained for each of the sites have the potential for effectively remediating the site, either alone or in combination with other technologies. The process used for BAAP technology screening is consistent with USEPA RI/FS guidance.

Remedial technologies retained after screening for each site were assembled into remedial alternatives. In developing the alternatives, consideration was given to the statutory preferences of the Superfund Amendments and Reauthorization Act, which states that alternatives retained for detailed analysis include no action, containment, and treatment alternatives. The selection of alternatives is also consistent with NCP Section 300.430(e)(3), which requires evaluation of a range of remedial alternatives (i.e., from alternatives that remove or destroy contaminants to the maximum extent feasible, to alternatives that provide little or no treatment but provide protection of human health and the environment) (USEPA, 1990).

The remedial alternatives were then screened on the basis of effectiveness, implementability, and cost. A summary of site-specific FS process results ranging from identification of contaminants of concern through screening of alternatives is presented in Table ES-1.

The alternatives retained after screening were evaluated in detail using criteria suggested in the RI/FS guidance. Detailed evaluation of the retained alternatives for each site and media is presented in Table ES-2. Based on the results of the detailed analysis and a comparison of the remedial alternatives, the Army recommends a remedial alternative for contaminated media at each of the sites. A summary of the recommended alternatives is presented in Table ES-3.

# 1.0 INTRODUCTION

This Feasibility Study (FS) report for the Badger Army Ammunition Plant (BAAP) in Baraboo, Wisconsin (Figure 1-1), was prepared by ABB Environmental Services, Inc. (ABB-ES), as a component of Task Order 1 of Contract DAAA15-91-D-0008 with the U.S. Army Environmental Center (USAEC). This report uses the results presented in the Final Remedial Investigation (RI) report (ABB-ES, 1993a) to develop and screen alternatives for remediation of contaminated media at BAAP.

The FS is being conducted to meet federal permit conditions issued by the U.S. Environmental Protection Agency (USEPA) Region V (USEPA, 1988a), under authority of the Resource Conservation and Recovery Act (RCRA); requirements set forth by the Wisconsin Department of Natural Resources (WDNR) in the In-Field Conditions Report (WDNR, 1987) and modifications to the In-Field Conditions Report (February 1990 and October 1992) under authority of the Wisconsin Environmental Response and Repair Regulations; and Wisconsin solid/hazardous waste regulations (i.e., Wisconsin Administrative Code [WAC] Chapter NR 600). In addition, FS activities were designed and conducted to meet the requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) by USAEC under the National Contingency Plan (NCP) 40 CFR 30. The policies and goals of the National Environmental Policy Act (NEPA) were also considered and incorporated into the FS Report.

Previous investigations at BAAP by Ayres Associates (Ayres), Eder Associates Consulting Engineers (Eder), Envirodyne Engineers, Inc. (EEI), Foth & Van Dyke Industrial, Inc. (Foth & Van Dyke), Olin Corporation (Olin), R.F. Sarko and Associates, Inc. (Sarko), Warzyn Engineering, Inc. (Warzyn), and others identified 11 potential hazardous waste sites requiring further investigation. Environmental data from these efforts were summarized in the Master Environmental Plan (MEP) prepared for BAAP by Argonne National Laboratory (Tsai, 1988). The MEP presented recommendations for RI activities, which were largely followed during initial RI activities. The 11 sites investigated by ABB-ES included the (1) Propellant Burning Ground, including Landfill 1, (2) Deterrent Burning Ground, (3) Existing Landfill, (4) Settling Ponds and Spoils Disposal Area, (5) Ballistics Pond, (6) Oleum Plant and Oleum Plant Pond, (7) Nitroglycerine Pond, (8) Rocket Paste Area, (9) New Acid Area, (10) Old Acid Area, and (11) Old Fuel Oil Tank. The general locations of these 11 sites are shown in Figure 1-2.

The remedial alternatives developed, screened, and evaluated in this report address the threat to human health and the environment from contaminated environmental media (i.e., soil, sediment, surface water, and groundwater), as reported in the RI report.

In this FS report, site summaries followed by alternatives development and screening are discussed on a site-by-site basis. The sites are addressed individually in Sections 3 through 7. Section 8 presents the retained alternatives and provides a convenient summary of similar remedial alternatives that will be evaluated at more than one site at BAAP. Sections 9 through 13 contain detailed analyses of the retained alternatives, including selection of the preferred remedial alternative for each site. USAEC acronyms and chemical codes are defined at the end of this report in the Glossary of Acronyms and Abbreviations and USAEC Chemical Codes.

Sections 3 and 9 in this FS Report specifically address contaminated environmental media (i.e., soil and groundwater) at the Propellant Burning Ground. Activities associated with groundwater remediation at the Propellant Burning Ground are proceeding according to an accelerated schedule that is separate from the schedule for completion of investigation, evaluation and implementation of corrective measures contained in the modifications to the In-Field Conditions Report (October 1992) set forth by the WDNR. Groundwater remediation is being conducted according to requirements set forth in the Modification of Conditional Plan Approval for the Interim Remedial Measures (IRM) Upgrade (WDNR, 1993). The IRM system is a groundwater treatment system that was designed, constructed, and is currently operating to capture the groundwater plume at the Propellant Burning Ground and prevent it from moving off BAAP property. Subsequent to construction of the IRM system, it was determined that the system is not effectively capturing all the plume (ABB-ES, 1993). Consequently, the IRM is being upgraded according to an accelerated schedule. Design of the IRM upgrade has been completed and bid documents for the construction of the system were made available to prospective bidders on July 18, 1994. Because the design of the IRM upgrade incorporates the preferred groundwater remedial alternative in the Draft Final FS Report, and remedial alternative selection is the end product of the FS process, no further revision or refinement of the groundwater remedial alternatives for the Propellant Burning Ground is necessary. Consequently, groundwater remedial alternative development in Section 3 and groundwater remedial alternative evaluation in Section 9 in this Final FS Report is the same as that presented in the Draft Final FS Report.

## 1.1 PURPOSE

The purpose of this FS report is to develop, screen, and evaluate site-specific remedial alternatives to mitigate the impact of site-derived chemicals and ultimately provide protection of human health and the environment. Preferred alternatives for each site are included in this report.

This FS report evaluates the information obtained during the RI, including site and waste characterizations, and the fate and transport of contaminants. This report also incorporates conclusions of the Human Health Evaluation and the Baseline Ecological Assessment from the RI report regarding the contaminants of concern, exposure pathways, and threats posed to human health and the environment from exposure to site contaminants. Remedial action objectives are developed based on reducing the exposure potential and/or concentration of contaminants in environmental media. Acceptable concentrations of contaminants in environmental media were derived from chemical-specific applicable or relevant and appropriate requirements (ARARs) and risk-based calculations. Acceptable concentrations of contaminants are identified as remediation goals (RGs) in this report. Remedial action objectives and RGs, along with a summary of the contamination assessment from the RI report, are presented for each site in each respective section.

Following development of remedial action objectives, each FS report Section 3 through Section 7 discusses site-specific remedial technology identification and screening, and discusses development and screening of remedial alternatives. The process involving technology identification through the screening of remedial alternatives is described in greater detail in Subsection 1.7.

Section 8 presents the remedial alternatives retained for contaminated environmental media for all the sites requiring remedial action, and highlights the remedial alternatives that are common to more than one site. Sections 9 through 13 present detailed evaluations of each retained alternative using evaluation criteria from the Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA, 1988b). Sections 9 through 13 also present the preferred alternative from those evaluated.

## 1.2 SCOPE

Based on previous environmental studies at BAAP, 11 potential hazardous waste sites were ranked according to potential contributions of hazardous chemicals to the environment (see Figure 1-2). These sites were designated as Waste Management Areas because some of the sites contain multiple Solid Waste Management Units (SWMUs). The sites selected to undergo facility assessment and corrective actions are: (1) the Propellant Burning Ground (including Landfill 1), (2) Deterrent Burning Ground, (3) Existing Landfill, (4) Settling Ponds and Spoils Disposal Area, (5) Rocket Paste Area, (6) Oleum Plant and Oleum Plant Pond, (7) Nitroglycerine Pond, (8) Old Acid Area, (9) New Acid Area, and (10) Ballistics Pond. The USAEC added an 11th site, the Old Fuel Oil Tank, to the list in October 1989 after discovery of fuel-contaminated soils during excavation of a water line in the vicinity of the old fuel oil tank foundation.

Although designated as Waste Management Areas containing one or more SWMUs, the 11 sites at BAAP are being investigated in the RI/FS under the U.S. Army Installation Restoration Program. The RI/FS follows CERCLA guidance and is designed to comply with requirements for the RCRA Facility Investigation and Corrective Measures Study (CMS).

After reviewing both the contamination assessment and the risk assessment conclusions from the RI report, the Army divided the 11 Waste Management Areas into two categories: (1) those sites where remediation is required because of documented risk to human health and/or the environment; and (2) those sites where remediation is not recommended because the sites were not identified as either a source of contamination to groundwater or a source of human health and environmental risks. These latter sites are the subject of a separate Decision Document prepared by ABB-ES. Table 1-1 lists the 11 Waste Management Areas assigned to each of these categories.

The five sites requiring remedial action are (1) the Propellant Burning Ground, (2) the Deterrent Burning Ground, (3) the Rocket Paste Area, (4) the Nitroglycerine Pond, and (5) the Settling Ponds and Spoils Disposal Area. Because of their proximity and because they are related hydrogeologically through a common drainage system, the Rocket Paste Area and Nitroglycerine Pond are combined as one site and referred to as the Nitroglycerine Pond and Rocket Paste Area (NG/RPA) throughout this report.

The six sites where the Army does not recommend remedial action are (1) the Existing Landfill, (2) the Oleum Plant and Oleum Plant Pond, (3) the Old Acid Area, (4) the New Acid Area, (5) the Ballistics Pond, and (6) the Old Fuel Oil Tank. A separate Decision Document (ABB-ES, 1993b) was prepared by ABB-ES to provide the rationale for no-action recommendations at these sites. The Decision Document contains histories of the sites, presents results of environmental investigations at the sites, and explains why no further action will be taken. These six sites will not be addressed further in this report other than references to how the geology/ hydrogeology of specific sites could affect contaminant transport at a neighboring site requiring remedial action.

### 1.2.1 Off-Post Contingency Plan

The Off-Post Contingency Plan (OCP) (ABB-ES, 1993c) was prepared as a separate document to recommend actions that should be taken if migration of site-related contaminants adversely impacts off-post residential water supplies. The information in the OCP enables a rapid response to protect public health in the unlikely event site-related contaminants should migrate to public and private water supplies from the Propellant Burning Ground in the southern part of BAAP, and from the Deterrent Burning Ground in the northeast part of BAAP.

This FS Report focuses on evaluating appropriate measures to be taken within BAAP boundaries to limit the spread of contamination. In addition, remedial alternatives for long-term solutions at the Off-Post Area south of BAAP are developed in this FS Report.

## 1.3 BACKGROUND

This subsection describes background information on the location, environmental setting, and operations history of BAAP.

BAAP is a government-owned, contractor-operated military industrial installation currently on standby status. BAAP is a facility of the Armament Munitions and Chemical Command (AMC COM) and is part of the U.S. Army Material Command (USAMC) headquartered at Rock Island, Illinois.

BAAP has been on standby status since 1977 and there are no plans to schedule the installation for closure. BAAP was twice placed in standby status then reactivated to support national emergencies. BAAP was reactivated to support the Korean

conflict in the 1950s and the Vietnam conflict in the 1960s. The history of BAAP demonstrates that an inactivated installation remaining in Department of the Army ownership is relatively common and does not trigger modification of land use or sale of the property. Therefore, future land use at BAAP is expected to remain substantially the same as current use, which is limited primarily to maintenance of production areas and restricted grazing, farming, and hunting activities.

Army industrial facilities similar to BAAP that have been previously decommissioned demonstrate that this type of facility is typically neither suited nor readily sold for unrestricted residential use. Included among these similar facilities are Volunteer Army Ammunition Plant and Newport Army Ammunition Plant, both of which were decommissioned during 1974-1975 and are currently used for limited industrial and recreational use. Like BAAP, these facilities are maintained in a standby condition for quick reactivation triggered by a national emergency.

### 1.3.1 Location

BAAP is located in south-central Wisconsin, approximately 9 miles south of Baraboo and 30 miles northwest of Madison (see Figure 1-1). BAAP covers approximately 7,354 acres within Sumpter and Merrimac townships in Sauk County. The installation is bounded by U.S. Route 12 on the west, Devil's Lake State Park on the north, and farmland on the south and east. State Highway 78 and Lake Wisconsin define the southeastern boundary. Lake Wisconsin was formed approximately 75 years ago by the construction of a power dam on the Wisconsin River 1.5 miles downstream and south of the installation boundary in the town of Prairie du Sac.

### 1.3.2 History of Industrial Operations

The following general history of industrial operations at BAAP was taken from the Installation Assessment of Badger Army Ammunition Plant, Report No. 111, May 1977, by USAEC. Site-specific histories and an overview of past practices at each of the 11 Waste Management Areas is described in subsequent site-specific sections.

The land required for the Badger Ordnance Works was procured by the government on March 1, 1942, and construction was started mid-year in 1942. A letter of intent was signed with Hercules Powder Company on November 10, 1941, authorizing it to initiate surveys and design the Wisconsin plant. The Hercules Powder Company was selected because it had successfully completed construction of the Radford Ordnance Works near Radford, Virginia, and the Badger plant was to be a duplicate of the

smokeless facilities at Radford. The plant was built by the Mason and Hanger Company of New York City.

BAAP production started in January 1943, and continued until September 1945, when the plant was placed on standby status. During this operational period, BAAP employed 7,500 people and manufactured 271 million pounds of single- and double-base propellant.

On December 15, 1945, BAAP was declared surplus by the U.S. Government. In October 1946, the rocket facilities were withdrawn from surplus and placed in standby status. From 1945 to 1950, various portions of BAAP were in surplus, standby, and caretaker status, and maintained by a small force of government employees. More than 4,189 acres were transferred during this time, of which 2.2 acres went to the Kingston Cemetery Association, 2,264 acres to the Farm Credit Administration, and 1,922 acres to the War Assets Administration, bringing the total acreage available for BAAP operations to 6,380 acres.

During the early 1950s, as a result of the plant's reactivation for the Korean conflict, 1,173 acres were reacquired, bringing the total acreage to 7,553 acres.

Rehabilitation of BAAP by the Fegles Construction Company was completed in 1955 and the Liberty Powder Defense Corporation was contracted to operate BAAP. Through merger, the company today is known as the Olin Corporation (Olin). Total production during this period (1951 to 1957) was approximately 286 million pounds of single- and double-base propellant, and employment peaked at 5,022 employees.

On March 1, 1958, BAAP was placed in inactive status. During this period, the land directly across from the main entrance on Route 12 was declared surplus and the acreage of BAAP was reduced to its present 7,354 acres.

The plant was reactivated effective December 23, 1965, with rehabilitation by Olin and various subcontractors. The manufactured propellants included ball powder, smokeless powder, and rocket propellant. Total production for this period was approximately 445 million pounds of single- and double-base propellant including 95 million pounds of ball propellant; 64 million pounds of rocket propellant; and 282 million pounds of smokeless powder. The plant employed 5,390 people at the peak of production during this period.

On March 24, 1975, the Department of Defense ordered production operations at BAAP to cease upon completion of current orders and placed the installation on standby status. This was the third such closure in the 50-year history of BAAP. Decontamination of facilities to the XXX condition (propellant was removed until no longer visible) was initiated by Olin immediately upon completion of production operations and was completed in March 1977.

Since 1977, a new continuous process nitroglycerine plant has been constructed, proved, and placed in standby. Other facilities constructed include an ammonia oxidation plant, nitric/sulfuric acid concentrators, and a sulfuric acid recovery plant.

### 1.3.3 Environmental Setting

This subsection describes the general environmental setting in and around BAAP and includes discussions of climate, physiography, geology, and hydrogeology.

**1.3.3.1 Climate.** The climate of Sauk County is continental. Because of its location in the interior of the North American continent, climatic extremes with wide variability from year to year are typical. Winter temperatures in Baraboo (December through February) average 18.4°F; the average summer temperature (June through August) is 68°F. The record high and low temperatures recorded at Baraboo are 101 and -45°F, respectively (National Oceanic and Atmospheric Administration, 1985).

Precipitation for the Baraboo area averages 30.9 inches annually. Approximately 21 inches of rainfall (70 percent of the annual total) typically falls during the growing season (April through September). Thunderstorms are common during this period, especially in June and July. The one- and 10-year, predicted maximum 24-hour rainfall totals for Sauk County are 2.3 and 4.1 inches, respectively.

The soil is typically frozen from early December until late March, with a frost penetration depth to 30 inches (Hellewell and Mattei, 1983). The average snowfall at Baraboo is 40.8 inches per season (November to April) (National Oceanic and Atmospheric Administration, 1985).

Prevailing winds in Sauk County are westerly in winter and southerly in summer, averaging 9 to 12 miles per hour. Highest windspeeds usually are recorded in March, April, and November (U.S. Department of Agriculture, 1980).

**1.3.3.2 Physiography**. BAAP is situated on the southern edge of the Baraboo Range, which consists of metamorphic quartzite rock of the Precambrian Period. Topography is defined by this upland region, as well as glacial features resulting from the advance of the Green Bay Lobe of the Cary Substage of the Wisconsin Stage glaciation approximately 12,000 years ago (U.S. Department of Agriculture, 1980). The Green Bay Lobe Glacier, which advanced from east to west, covered the eastern two-thirds of BAAP before retreating. The terminal moraine of the Wisconsin Stage glacier extends from north to south across the central portion of the ammunition plant. Topography east of the terminal moraine is gently undulating to hilly with complex slopes and numerous depressions; the outwash plain west of the terminal moraine is nearly level to gently sloping. Surficial soils in most areas at BAAP consist of fine-grained sandy silts characterized as windblown loess deposits.

Generally, most precipitation falling on BAAP either evapotranspirates or infiltrates to the groundwater system through the sand and gravel. The overall direction of surface drainage at BAAP is to the south and is partially controlled by man-made ditches. However, in the northwest portion of the site, ditches convey runoff to Ballistics Creek, which flows west from BAAP to Otter Creek. Nineteen ponds are present on site, although most are dry throughout much of the year. Many ponds are not drained by surface streams. Ponds that contain water throughout most of the year such as the Ballistics, Nitroglycerine, and Rocket Paste ponds represent perched water caused by the accumulation of fine sediments in the bottom of each pond.

**1.3.3.3 Geology**. The geologic setting at BAAP is generally characterized by a thick sequence of unconsolidated soil units deposited in association with late Quaternary glacial advance and retreat. These unconsolidated soil units are underlain by sedimentary and metamorphic bedrock dating to the Cambrian and Precambrian periods.

At the ground surface across most of BAAP, a 5- to 10-foot-thick fine-grained clayey silt unit (i.e., loess) overlies glacially derived soil deposits. The loess, representing windblown soil, comes from soil material exposed along outwash valleys during and after glacial retreat. The loess is laterally extensive in this region and tends to become thicker toward the Mississippi River (i.e., to the west).

During late Wisconsin Stage glaciation, the Green Bay Lobe Glacier advanced across the site from east to west covering approximately the eastern two-thirds of BAAP. This marked the maximum glacial advance of the Green Bay Lobe and is today represented by a terminal moraine ridge approximately 60 feet high, transecting

BAAP from north to south (Alden, 1918; Thwaites, 1958). This moraine, named the Johnstown Moraine, is laterally extensive in southern Wisconsin (Clayton, 1989).

Unconsolidated glacial deposits, consisting primarily of sands and gravels, thicken from north to south in the northern portion of BAAP. Along the northern site boundary, soil deposits are thin or absent and bedrock outcrops are common. However, the bedrock surface dips steeply toward the south and soil deposits quickly thicken to a maximum of approximately 250 feet. Figure 1-3 illustrates a regional bedrock contour plan for the BAAP region based on monitoring well and private water supply well logs. The figure indicates the bedrock surface drops approximately 150 to 200 feet across the northern third of BAAP. Across the southern two-thirds of BAAP, the bedrock surface appears flat.

**1.3.3.4 Hydrogeology**. The principal groundwater flow system beneath BAAP occurs in the unconsolidated overburden soils. This aquifer is unconfined, receiving recharge from infiltrating precipitation and discharging groundwater to the Wisconsin River south of the Wisconsin Power and Light (WP&L) dam. Figure 1-4, a regional water table contour map for BAAP, indicates groundwater flows toward the southeast in the northwestern portion of the site and toward the south throughout much of the remainder of the site, with some southwesterly flow near the Lake Wisconsin Reservoir along the eastern base boundary. Along the northern BAAP boundary, a complex hydrogeologic condition exists featuring water table and steep gradients. The gradient on the water table flattens substantially and the flow direction changes from southeasterly to southerly across the central and southern portion of BAAP with likely discharge to the Wisconsin River, or flows south within the sand and gravel beneath the river south of the WP&L dam.

The overall water budget for precipitation at the site is dominated by evapotranspiration, which accounts for approximately two-thirds to three-fourths of the average 30 inches of precipitation in this area. Surface water runoff at BAAP is limited, and much runoff that occurs collects in isolated depressions where it slowly infiltrates or evaporates during summer months. Recharge to the aquifer is limited by infiltration through the fine-grained loess unit blanketing the region. The site-specific water balance estimate for this area indicates a recharge rate on the order of 5 to 7 inches per year in areas where the loess layer is present. Where the loess layer is absent and only fine-grained sands are present at ground surface, the infiltration rate estimate increases to 7 to 9 inches per year.

In the northern portion of BAAP, infiltrating precipitation and groundwater discharge from bedrock could encounter fine-grained glaciolacustrine layers before reaching the water table. This condition results in formation of a locally elevated groundwater flow system. The fine-grained glaciolacustrine soils appear to generate locally semi-confined conditions in the underlying aquifer. This assessment is based on the discontinuous nature of the glaciolacustrine unit, and the locally irregular groundwater elevations beneath the glaciolacustrine unit in comparison with the regional water table elevation. Downward vertical gradients are present across the unit. The presence of fine-grained glaciolacustrine soils and higher elevations of the bedrock surface also appear responsible for the steeper gradients observed in the northwestern portion of BAAP, as indicated in Figure 1-4.

In central and southern portions of BAAP, the glaciolacustrine layers are absent and the horizontal gradient across the water table is substantially reduced. This condition is reflected in the flattened surface of the water table (see Figure 1-4). Groundwater flow across the southern portion of BAAP is influenced by the WP&L dam on the Wisconsin River, which creates the Lake Wisconsin Reservoir. This reservoir extends north of the dam along the southeastern BAAP boundary and has an approximate 40-foot head drop at the dam. The water level in the reservoir (approximately 774 feet above mean sea level [MSL]) is elevated above the water table over much of the southeastern portion of BAAP. This prevents expected groundwater discharge to the reservoir and creates the potential for seepage from the reservoir to recharge the groundwater in this area. The net result is groundwater flow parallel to the reservoir with discharge to, or flow beneath, the river south of the WP&L dam. These flow variations are illustrated in Figure 1-4. The influence of the reservoir on the groundwater flow system appears to extend to the northeastern portion of BAAP. It appears that groundwater flow in the northeastern portion of BAAP has a southeastern flow direction that slowly turns toward the southwest to flow parallel to the Lake Wisconsin Reservoir.

It should be noted that if groundwater from the northeastern portion of BAAP discharged to Wiegand's Bay there would be no substantial impact to Wiegand's Bay or the surrounding area. Groundwater monitoring along the northeast BAAP boundary has shown minimal impact to groundwater quality from site-related activities. Sulfate (SO4) is the only site-related compound detected along the site boundary that appears attributable to site activities. However, the SO4 concentrations detected exceed the Wisconsin Preventive Action Limit (WPAL) but do not exceed the Wisconsin Enforcement Standard (WES). Further, SO4 is only

regulated as a secondary or public welfare standard, not as a primary or public health standard.

Groundwater resources in the BAAP region are used for domestic and municipal water supply, cropland irrigation, and commercial/industrial production. Well installation logs for those wells on file with the Wisconsin Geologic and Natural History Survey and WDNR have been collected and are included in the RI Report (ABB-ES, 1993a).

## 1.4 BACKGROUND FOR HUMAN HEALTH AND ECOLOGICAL RISK CHARACTERIZATION

This subsection is to be used as a reference when reviewing the human health and ecological risk characterizations in Sections 3 through 7. The text in those sections identify risk levels derived using the methods summarized in this subsection. The methods used for the human health evaluation and baseline ecological risk assessment are described in detail in the RI Report (ABB-ES, 1993a).

### 1.4.1 Human Health Risk Characterization

A baseline human health risk assessment was conducted as part of the RI Report (ABB-ES, 1993a). The methodology of the risk assessment was consistent with relevant USEPA standards and guidance. Risks were estimated for carcinogenic and noncarcinogenic effects of chemicals of concern identified for each area evaluated at BAAP.

The significance of risk estimates was evaluated by comparing risks to established target levels. USEPA has established target levels for the evaluation of carcinogenic risks and noncarcinogenic hazards at hazardous waste sites. USEPA's guidelines state that the total incremental carcinogenic risk for an individual resulting from multiple-pathway exposures at a Superfund site should not exceed a range of $10^{-6}$ to $10^{-4}$ (USEPA, 1989a). Therefore, risk characterizations identify carcinogenic risk estimates as being "below the target range" when risks are less than $10^{-6}$; "within the target range" when risks are between $10^{-6}$ and $10^{-4}$; and "above the target range" when risks are greater than $10^{-4}$. The target hazard level for noncarcinogenic effects is a Hazard Index (HI) of 1 (USEPA, 1989a).

Risk Characterization of Exposure to Lead. Because USEPA has not published dose-response values for carcinogenic or noncarcinogenic effects of lead (PB), a

quantitative expression of risk cannot be developed. However, there is an interim guidance document (USEPA, 1989c) establishing soil cleanup levels for PB of 500 to 1,000 parts per million (ppm). The range is designed to be protective of human health based on blood lead levels in children (a sensitive subpopulation) exposed to lead in a residential setting. Concentrations of PB detected at each Waste Management Area were compared to the level set forth in this guidance to establish whether it poses a risk to human health.

Qualitative Evaluation of Groundwater Quality. Both Wisconsin and the federal government have developed health-based standards for contaminant levels in groundwater. Therefore, groundwater quality was evaluated qualitatively by comparison to these guidelines and standards. Contaminant concentrations in groundwater at each site were compared to four types of groundwater and drinking water guidelines and standards:

- USEPA Maximum Contaminant Level Goals (MCLGs)
- USEPA Maximum Contaminant Levels (MCLs)

The USEPA Office of Drinking Water develops MCLGs based solely on a consideration of the potential adverse health effects of a chemical in drinking water. If a chemical is a carcinogen, the MCLG is always set at zero. An MCL is a legally enforceable standard set as close to the MCLG as possible, taking cost and technical limitations into account. The WESs are enforceable standards applicable to groundwater supplies in Wisconsin (WDNR, 1990). They do not apply to public water systems. WPALs are set at 10 percent of the WES for all substances that have carcinogenic, mutagenic, or teratogenic properties, and at 20 percent of the WES for all other substances.

Neither USEPA nor WDNR have promulgated standards for some of the compounds detected in groundwater at BAAP. Concentration levels protective of human health were calculated for these compounds based on exposure of an adult resident drinking 2 liters of water per day for 30 years. The equation and exposure assumptions are presented in the RI Report (ABB-ES, 1993a). The target levels were set at a risk level of $1x10^{-6}$ or an HI of 1. Detected concentrations of these compounds were compared to the calculated concentrations to determine whether the chemicals of concern (COC) might pose risks to human health.

The risk characterization process identified contaminants present in a given medium at concentrations which potentially cause adverse health effects. Numeric clean-up standards were developed for soil contaminants in accordance with the proposed Wisconsin Chapter NR 720 guidance for protection of human health from direct contact with soil at an industrial site. Because BAAP is currently on standby status and will remain a government-owned facility for the foreseeable future, the industrial scenario was selected as being more appropriate than a nonindustrial site scenario. The clean-up standard is designed to be protective for direct contact through incidental ingestion of and inhalation of particulate matter from contaminated soil by a worker. Incidental ingestion is assumed to be 100 milligrams (mg) per day for a 70 kilogram (kg) adult worker for 245 days each year and inhalation of particulate matter is assumed to occur at an inhalation rate of 24 cubic meter ($m^3$) of air per day with a concentration of 1.4 micrograms per cubic meter ($\mu g/m^3$) of contaminated soil particles less than 10 $\mu$m in diameter per day for 25 years in a 70 year lifetime. The standard is developed to evaluate a target excess cancer risk of $1x10^{-6}$ and a target hazard quotient (HQ) of 1.0 for noncarcinogens.

Table 1-2 presents these exposure assumptions and the equations used to calculate the soil standard. The equations are based on those given for an industrial worker in "Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals)" (USEPA, 1991). The cancer slope factors (CSFs) and reference doses (RfDs) for oral and inhalation effects are obtained from USEPA's Integrated Risk Information System (IRIS) (USEPA, 1994). For values not available from this source, the USEPA Health Effects Assessment Summary Tables (HEAST) were consulted (USEPA, 1993). Separate clean-up standards were calculated for carcinogenic and noncarcinogenic effects, as displayed in Table 1-2. In instances where both carcinogenic and noncarcinogenic standards were developed, the lower of the two concentrations was chosen as the clean-up standard.

### 1.4.2 Ecological Risk Characterization

**1.4.2.1 Risks Associated with Surface Water Exposure.** Comparison of contaminant concentrations detected in BAAP wetland surface water with reference toxicity values (RTVs) for aquatic organisms provides a means to evaluate the potential for adverse effects on aquatic environmental receptors from exposure to surface water contaminants. For each study area, comparisons have been made between the surface water RTV and the estimated exposure point concentrations of BAAP surface water COCs.

**1.4.2.2 Risks Associated with Sediment Exposure.** Comparison of the contaminant concentrations detected in BAAP sediments with RTVs for aquatic organisms provides a means to evaluate the potential for adverse effects on aquatic environmental receptors from exposure to sediment contaminants. To evaluate risk associated with exposure to contaminated sediment at BAAP, comparisons were made between the sediment RTVs and exposure point concentrations of BAAP sediment COCs.

**1.4.2.3 Risks to Terrestrial Receptors.** Risks to terrestrial receptors at BAAP were quantitatively evaluated using HQs, which were calculated for each COC by dividing the estimated exposure level, in terms of total body dose (TBD), by the toxicological benchmark (the RTV). To calculate acute exposure HIs, the site-specific exposure point concentration of each COC was divided by the acute RTV; chronic exposure HIs were calculated by dividing the site-specific exposure point COC concentrations by the appropriate chronic RTV. This conservative approach provides a screening level evaluation of potential effects of individual COCs on terrestrial ecological receptors.

Cumulative HIs were determined by summing the HQs for each chemical. A hazard ranking system developed by USEPA (1989a) was used to characterize the potential risk associated with exposures to BAAP contaminants. Cumulative HI scores were classified using the following USEPA (1989a) ranking system:

| HAZARD INDEX | EFFECTS EXPECTED |
|---|---|
| HI < 0.1 | No Adverse Effects |
| 0.1 < = HI < 10 | Possible Adverse Effects |
| HI > = 10 | Probable Adverse Effects |

This ranking system considers potential ecological effects to individual organisms, and does not evaluate potential population-wide risks. Contaminants may cause population reductions by affecting birth and mortality rates, immigration, and emigration (USEPA, 1989a). In many circumstances, acute (or chronic) effects can occur to individual organisms with little potential population or community level effects; however, as the number of individual organisms experiencing toxic effects increases, the probability that population-level effects will occur also increases. The number of affected individuals in a population presumably increases with increasing HI values; therefore, the likelihood of population-level effects occurring is generally expected to increase with higher HI values.

The TBD estimates the combined effects of exposure to contaminated BAAP surface soil. The TBD for each constituent was compared to the acute and chronic RTVs to develop acute and chronic HIs. Cumulative acute and chronic HIs were determined by summing the acute and chronic HQs for each contaminant; these results were evaluated using the hazard ranking scheme described above.

### 1.5 Background for Soil Contaminant Modeling

This subsection presents a description of the modeling performed to estimate the impact to groundwater quality posed by contaminants at the Waste Management Areas evaluated in the FS. The potential for contaminants in soil to migrate to and impact groundwater is assessed via the modeling effort. Modeling results are used in selecting chemical-specific cleanup levels as described in the FS report.

As a first step in the modeling process, a screening level using the organic leaching model (OLM) for organics, and a linear partitioning model for metals, was conducted for all compounds for which a WPAL was available. This was coupled with estimates of mixing factors of leachate with groundwater based on the site size, recharge and groundwater flow beneath the site. For compounds which were still of concern, more detailed modeling was conducted to include: (1) effects of partitioning through the soil column, volatilization, and degradation of the organics, and (2) partitioning of the metals. The models used and the input parameters are described in the following paragraphs. No modeling was attempted for anionic contaminants of concern (sulfate, nitrate/nitrite, or chloride) because no models exist to predict concentrations during migration of these constituents.

**Mixing Factors.** Dilution mixing factors for leachate reaching the groundwater were estimated from a mass balance approach. Site areas and groundwater flow velocities were estimated based on RI data, and the recharge and mixing zones were taken as the default values of 10 inches per year and 10 feet below ground surface, respectively, unless site-specific data were available to provide other values.

**Screening Level Models.** The OLM is an empirical expression relating estimated leachate concentration to the compound solubility in water and concentration in waste or soil. It was derived by USEPA for the RCRA program from a large database of leachate and soil concentrations for a large number of sites. While the model is not site-specific, it does represent a best-fit estimate for leaching concentrations under actual site conditions.

The linear partitioning model (often called the Summers model when coupled with the mixing zone dilution factor) is based on a simple equilibrium of leachate and soil concentrations. The model is generally very conservative, as the partition coefficients are determined from well-mixed solid and liquid phases, and from sorption rather than desorption experiments.

Neither of the screening models considers other factors which may significantly affect migration potential or concentrations as the contaminant migrates. Where significant soil column thickness exists between the contaminant and the groundwater table, the result of volatilization, partitioning and degradation processes can greatly lower contaminant concentrations along the pathway, and eventually decrease the leachate concentrations actually reaching the groundwater.

**Jury Model.** The Jury model is a one-dimensional transport model which includes effects of linear partitioning, dispersion, volatilization, and degradation processes. The Jury model assumes a uniform distribution of contaminant within a zone of specified thickness and depth within the soil column. Soil properties are entered as are the chemical/physical properties of the contaminant. Migration of single constituents is considered by the model requiring multiple runs for a range of constituents and distributions.

**Model Input Parameters.** Mixing zone dilution factors were calculated from data from the RI and default values for recharge and zone thickness. The required data also include source area size and orientation to flow, aquifer hydraulic conductivity, and hydraulic gradient. In several instances, it was possible to determine a single mixing zone factor for a number of similar sites (e.g., the spoil piles or the settling

ponds), using a minimum or representative value for the mixing factor for these locations.

The leaching portion of the Summers model requires a $K_d$ value which has been taken as literature-derived organic carbon partition coefficient $K_{oc}$ values (USEPA, 1989d) times an assumed fraction organic carbon ($f_{oc}$) of 0.1% or 0.001. This is conservatively low, but reasonable for sand and gravel soils. No data was available in the literature for barium or mercury, and so these two metals were not modeled.

The OLM expression can be rearranged algebraically to solve for the soil target level. The OLM requires the water solubility of the compound as input rather than the $K_d$. Solubility values are available for all organic compounds of concern from the literature.

The Jury model requires a number of parameter values to describe the water-soil, and water-air partitioning equilibria, degradation rate constants, and migration rates.

**Results of the Modeling.** As expected, the OLM provided somewhat higher soil target levels than the linear partitioning model for most of the compounds. For many compounds, the projected soil target levels estimated by the more conservative Summers model were below detectable limits. Only in a couple of instances were compounds eliminated by the screening level analysis, and the next step in the modeling process (use of the Jury model) was undertaken.

The Jury model indicated that in most instances, the added attenuation provided by volatilization and mainly degradation was sufficient to protect groundwater to the low WPAL criteria. Bis(2-ethylhexyl)phthalate (B2EHP), benzene (C6H6), trichloroethylene (TRCLE), and for most areas, 2,6-dinitrotoluene (26-DNT), gave soil targets above maximum detected values.

The modeling for the metals at the screening level did not include any mechanisms that would attenuate migration other than by retarding migration rates. Hence, the source area is modeled as having nearly a direct impact on groundwater, but with a delay in time. For most metals, migration travel times were between several hundred to several thousand years, indicating the relative immobility of the metals.

**Conclusions.** While the modeling has demonstrated a probable lack of impact of most organics at the various sites on groundwater (relative to WPALs), it indicates

a potential for impact on groundwater at some areas for 24-DNT and for metals. A more detailed description of the modeling is presented in Appendix A.

## 1.6 REMEDIATION GOALS

After results of the contamination assessment and both human health and ecological risk characterization were evaluated, RGs were developed. RGs consist of medium-specific goals for protecting human health and the environment. Site-specific RGs at BAAP were developed for a combination of one or more of the following media:

- surface soil
- sediment
- subsurface soil
- surface water
- groundwater

For soil and sediment, the RGs were set at the ecological risk-based concentration, the human health risk-based concentration, values associated with the compound's potential to migrate to groundwater, or, if available, at the background soil concentration. Although background concentrations of certain inorganic chemicals exceed ecological risk-based values, there would be no significant benefit gained to populations of terrestrial organisms within BAAP by remediating isolated areas to below background. Additionally, many ecological risk-based values are below laboratory detection limits and would likely be unattainable by soil remediation.

RGs for surface water were set at ecological risk-based values.

Groundwater RGs were set at regulatory standards or at human health risk-based values.

RGs are presented on a site-specific basis in Subsections 3.4, 4.4, 5.4, 6.4, and 7.4.

## 1.7 ALTERNATIVES DEVELOPMENT AND SCREENING PROCESS

Development of alternatives to meet remediation goals begins with the identification and screening of potentially applicable remedial technologies. Technology identification and screening was initially performed in the Remedial Technology

Handbook (Appendix B). Technologies were screened in the handbook by evaluating technical implementability at BAAP. Those remaining after initial screening are described in the handbook on the basis of three broad categories: effectiveness, implementability, and cost. Screened technologies included those that isolate contaminants from potential receptors and those that treat contaminated media to reduce the concentration of contaminants available to potential receptors.

The Remedial Technology Handbook serves as the primary source of information for remedial technologies identified for each site addressed in this report. Other sources of information included technology literature, vendor information, and FSs prepared by ABB-ES. Site and waste characteristics were considered during the identification process. Site characteristics considered included the following:

- site geology, hydrogeology, and terrain
- availability of space, and resources necessary to implement the technology
- presence of special site features

Waste characteristics considered included the following:

- types and concentrations of contaminants
- physical and chemical properties of contaminants (e.g., volatility, solubility, and mobility)

The number of identified technologies was reduced during a further screening in this report during which the advantages and disadvantages of the effectiveness and implementability of each technology were evaluated. Technologies that were retained for each of the sites have the potential for effectively remediating the site, either alone or in combination with other technologies. The process used for BAAP technology screening is consistent with the USEPA RI/FS guidance.

Remedial technologies retained for each site after screening were assembled into remedial alternatives. In developing the alternatives, consideration was given to the statutory preferences of the Superfund Amendments and Reauthorization Act (SARA), which states that alternatives retained for detailed analysis include no action, containment, and treatment alternatives. The selection of alternatives is also

consistent with the NCP Section 300.430(e)(3), which requires evaluation of a range of remedial alternatives (i.e., from alternatives that remove or destroy contaminants to the maximum extent feasible, to alternatives that provide little or no treatment but provide protection of human health and the environment) (USEPA, 1990).

The remedial alternatives were then screened on the basis of effectiveness, implementability, and cost. Components considered for each of the evaluation criteria are presented in Figure 1-5. The alternatives retained after screening were evaluated in detail using the criteria suggested in the RI/FS guidance and presented in Table 1-3. Based on the results of the detailed analysis and a comparison of the remedial alternatives, the Army recommends a remedial alternative for contaminated media at each of the sites described in Sections 8, 9, 10, 11, and 12.

# 2.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 121 of CERCLA requires conformance with ARARs of federal and state regulations if a hazardous substance is to remain on site as a result of remedial action.

CERCLA also requires that selected remedial actions are protective of human health and the environment. During the RI/FS, ARARs are employed in the development of remedial response objectives, remedial action alternatives, and site-specific clean-up goals. The determination of an alternative's protectiveness requires an evaluation with respect to site-specific ARARs and risk factors. Acceptable exposure levels can then be established through review and analysis of ARARs, if available, and risk factors, which evaluate systemic toxicant, carcinogens, and other factors related to exposure. ARARs can define cleanup goals when they set an acceptable risk level with respect to site-specific factors. Where ARARs do not exist or would not be sufficiently protective for the given circumstance, requirements to be considered (TBCs) and risk assessment-based data can be used to develop cleanup goals.

## 2.1 DEFINITION OF ARARS

Development of a comprehensive inventory of ARARs involves a two-tiered analysis: a determination of the applicability of an environmental regulation; and an evaluation of relevancy and appropriateness if the regulation is not applicable. A requirement may be either "applicable" or "relevant and appropriate," but not both.

An **applicable** requirement, as defined in Section 300.5 of the NCP, is a cleanup standard or other substantive requirement promulgated under federal or state environmental laws that *specifically* addresses the hazardous substance, the remedial action, the location, or other circumstance found at a CERCLA site. Only those state standards identified by the state in a timely manner and that are more stringent than the applicable federal standard may be applicable.

A requirement that is **relevant and appropriate** for use as a cleanup standard at a CERCLA site is a cleanup standard or other substantive requirement that, while not "applicable" to a hazardous substance, remedial action, location, or other circumstance found at the site, addresses problems or situations sufficiently similar to those found at the site that its use is well suited to the particular site. Only those

state standards identified by the state in a timely manner and that are more stringent than the applicable federal standard may be relevant and appropriate. To be used as a cleanup standard, a relevant and appropriate requirement must be found to be both relevant and appropriate.

In addition to the above criteria, TBCs, which are nonpromulgated advisories or guidance issued by federal or state governments, are not legally binding, and do not have status as potential ARARs, will be evaluated. In some circumstances, the TBCs will be considered along with ARARs and risk assessment results and may be used in developing the cleanup levels for individual sites. TBCs can be useful in helping evaluate what is protective at a site or how to carry out certain actions or requirements.

## 2.2 IDENTIFICATION OF ARARs

Requirements that govern actions at CERCLA sites, and which are therefore used to define the requirements for RCRA-directed Waste Management Areas at BAAP, can be categorized into three distinct areas:

- **Chemical-specific requirements** are usually health- or risk-based standards that limit the concentration of a chemical found in or discharged to the environment. They govern the extent of site remediation by providing either actual cleanup levels, or the basis for calculating such levels. For example, groundwater standards can provide the necessary cleanup goals for the Waste Management Areas with contaminated groundwater at BAAP. Chemical-specific ARARs for the Waste Management Area may also be used to indicate acceptable levels of discharge in determining treatment and disposal requirements, and to assess the effectiveness of future remedial alternatives.

- **Location-specific requirements** govern special locations (e.g., wetlands, floodplains, and sensitive ecosystems) and man-made features (e.g., landfills, disposal areas, and places of historical or archeological significance). These ARARs generally place restrictions on the concentrations of hazardous substances or the conduct of activities solely based on the site's particular location.

- **Action-specific requirements** involve performance, design, or other action-specific requirements and are generally technology- or activity-based. As remedial alternatives are developed, action-specific ARARs (pertaining to proposed remedies) provide a basis for assessing their feasibility and effectiveness.

Many regulations can fall into two or more categories. For example, many location-specific ARARs are also action-specific because they are triggered if remedial activities impact special locations. Likewise, many chemical-specific ARARs are also location-specific. For example, Wisconsin Administrative Code (WAC) Water Quality Standards for Wetlands (WAC, 1989) is both a location-specific ARAR because it pertains only to wetlands, and a chemical-specific ARAR because it establishes a methodology for calculating cleanup levels for wetlands. Where a regulation has been determined to meet the definition of more than one category, the potential ARAR has been listed or discussed in the category judged most pertinent.

The identification of ARARs, along with other available nonpromulgated advisory and guidance material, is an important component in the planning, evaluation, and selection of remedial actions during remediation planning. Individual ARARs should be identified at several points in the remedial response process. They must be identified on a site-specific basis, and therefore, as additional information is developed about the Waste Management Area through ongoing RI/FS activities, the ARARs will be progressively refined.

Finally, CERCLA §121 provides that under certain circumstances an otherwise applicable or relevant and appropriate requirement may be waived. These waivers apply only to meeting ARARs with respect to remedial actions on site; other statutory requirements, such as that remedies be protective of human health and the environment, cannot be waived. If a waiver is required, this would be identified and discussed during the detailed analysis of alternatives in the FS report.

## 2.3 Applicability of Regulatory Requirements at Federal Facilities

Section 120 of CERCLA provides guidelines for remediation of hazardous constituents released from federal facilities. CERCLA requires that each department, agency, and instrumentality of the United States (i.e., federal facility), including the executive, legislative, and judicial branches of government, be subject

to and comply with CERCLA, both procedurally and substantively, in the same manner and to the same extent as any nongovernmental entity. All guidelines, rules, regulations, and criteria carried out under CERCLA, including the NCP, are applicable to federal facilities. Therefore, like any other facility, federal facilities are subject to preliminary assessment, priority listing, and remedial action selection requirements. In addition, federal facilities must comply with the same cleanup standards, including federal and state ARARs.

Depending on the status of the federal facility (i.e., National Priorities List [NPL] site, non-NPL site, or RCRA facility), remedial action will be conducted under different authorities. Under Executive Order 12580 (i.e., Superfund Implementation), USEPA was delegated authority to govern the extent of remedies at federal facilities on the NPL. For federal facilities not on the NPL, the Secretary of Defense was delegated the authority to select remedial actions. Section 2701 of CERCLA (i.e., the Environmental Restoration Program) authorizes the Secretary of Defense to carry out a program of environmental restoration at facilities under his/her jurisdiction. Program activities must be carried out consistently with Section 120 of CERCLA, in consultations with the Administrator of the USEPA. State laws concerning hazardous waste removal and remedial actions are still applicable to non-NPL federal facilities by virtue of Section 120(a)(4) of CERCLA.

Because the BAAP facility is a RCRA-permitted hazardous waste management unit, RCRA regulations are applicable whether or not the facility is on the NPL. RCRA Section 3004 requires RCRA corrective action for all releases of hazardous waste constituents at a RCRA-permitted facility, regardless of when the waste was disposed of. Therefore, if there were a release of hazardous waste or constituents from a unit or activity located within the facility boundaries, regardless of whether the unit or activity was intended for treatment, storage, or disposal (TSD) of RCRA waste, site cleanup would come under the jurisdiction of the federal RCRA or state RCRA-authorized program. If the federal facility is a RCRA-regulated hazardous waste management unit, hazardous waste contamination within the facility boundaries is subject to RCRA corrective action authority. Because CERCLA has encompassed the concept of relevant and appropriate requirements, the resulting remedies are generally considered to be as or more protective of human health and the environment than RCRA corrective actions. Therefore, the decision to conduct the investigation and the subsequent remedies within the CERCLA framework is considered a conservative approach to site remediation.

To date, BAAP has not been listed on the NPL. BAAP operates a RCRA TSD facility licensed under a Joint Operating Permit issued by WDNR and USEPA. The Federal Permit portion of the Joint Permit (USEPA, 1988a) contains the requirement to perform further investigation and/or corrective action at a number of Waste Management Areas, including those addressed in this report. In addition, WDNR has issued an In-Field Conditions Report Approval (WDNR, 1992) that requires monitoring, investigations, and the remedial actions at BAAP currently being evaluated.

## 2.4 CURRENT REGULATORY STATUS OF SOLID WASTE MANAGEMENT UNITS AT BAAP

As discussed in Subsection 2.3, conditions in the BAAP Joint Operating Permit require further investigation and/or corrective action at BAAP. The permit, issued on October 30, 1988, contains both USEPA conditions and WDNR conditions issued by Wisconsin's RCRA program. Wisconsin is authorized to administer the base RCRA program as well as the Hazardous and Solid Waste Act (HSWA). Therefore, the permit conditions, which are administered by USEPA, address HSWA requirements, including Corrective Action.

As part of the USEPA permit conditions, a RCRA Facility Investigation (RFI) and CMS program have been outlined. RFI requirements are being satisfied by the RI, and the CMS requirements are being addressed by the FS. BAAP must also comply with the conditions of the WDNR In-Field Conditions Report Approval and subsequent modifications (WDNR, 1992).

## 2.5 IDENTIFICATION OF LOCATION-SPECIFIC ARARS

As discussed in Subsection 2.3, federal facilities must comply with federal and state ARARs. Therefore, potential location-specific ARARs were identified based on a review of potential ARARs listed in the NCP preamble, WDNR regulations, and a review of BAAP potential special locations.

RCRA Subpart N and Wisconsin solid and hazardous waste management regulations play an important role where landfills and surface impoundments are identified as a site feature. Other regulations relevant to BAAP include the NEPA and the Clean Water Act (CWA) along with WDNR regulations governing surface water and wetlands. Remedial actions addressing contaminated sediments and surface waters

should meet the requirements of these regulations. NEPA requires that federal agencies include in their decision-making processes appropriate and careful consideration of all environmental effects of proposed actions, avoid or minimize adverse effects of the proposed actions, and restore and enhance environmental quality as much as possible. A remedial alternative affecting a wetland or floodplain may not be selected unless a determination is made that no practicable alternative exists outside the wetland. If no practicable alternative exists, potential harm must be minimized and action taken to restore and preserve natural and beneficial value. Additionally, Section 404 of the CWA regulates discharge of dredged and fill materials to waters of the United States. Remedial actions within wetlands would require a 404 permit. These regulations along with Wisconsin Statutes Annotated, Chapter 30, Dredge and Fill Requirements, provide direction with respect to management of dredged materials.

The Clean Air Act (CAA) (40 CFR Part 52) defines requirements for "major sources" of emissions. Emission limitations for major sources vary based upon the designation of the site as being within an "attainment" or a "non-attainment" area. Attainment areas are those regions of the country that are designated as being in compliance with the National Ambient Air Quality Standards (NAAQS) priority pollutants. Non-attainment areas are those parts of the country where compliance has not been attained for one or several criteria pollutants. Sauk County, in which BAAP is located, is designated as an attainment area for all regulated air pollutants. Prevention of Significant Deterioration (PSD) requirements apply to attainment areas.

Because of the location of the facility within an attainment area, PSD regulations apply. The PSD regulations classify PSD areas as either Class I, Class II, or Class III. The classification of a particular area within a state is established within the State Implementation Plan (SIP) for CAA requirements. Sauk County, Wisconsin, is within the Southern Wisconsin Intrastate Air Quality Control Region. This region is designated as Class II for particulate matter, and Class II for all other regulated pollutants. Allowable PSD increments for each class are listed in Appendix A of the Final RI Report (ABB-ES, 1993a).

In addition, the Fish and Wildlife Coordination Act (16 USC 661 et seq.) requires that before issuing a federal permit or undertaking any federal action that causes the impoundment, diversion, or other control or modification of any body of water, the applicable federal agency must consult with (1) the appropriate state agency exercising jurisdictions over wildlife resources; (2) the U.S. Fish and Wildlife Service,

and (3) the National Marine Fisheries Service. Under 40 CFR 6.302(f), reports and recommendations of wildlife agencies should be incorporated into environmental assessments. Table 2-1 is a checklist of the environmental settings and features of the 11 BAAP sites. Table 2-2 summarizes the potential location-specific ARARs for the features at each site. Synopses of potential location-specific ARARs are presented in Appendix C.

## 2.6 Identification of Chemical-Specific ARARs

As discussed in Subsection 2.2, chemical-specific ARARs are usually health- or risk-based values that limit the concentration of a chemical found in or discharged to the environment. Federal regulations setting forth chemical-specific requirements for hazardous waste remediation include the Safe Drinking Water Act (SDWA), RCRA, HSWA, and the CWA. The State of Wisconsin also has promulgated a number of regulations that are parallel to, and in some cases more stringent than, federal requirements. A brief summary of key chemical-specific ARARs issues is presented by environmental media in Table 2-3, which lists the identified ARARs by media. Specific standards and guidance values for groundwater chemicals identified at BAAP are tabulated in Table 2-4. A more complete discussion of the identified chemical-specific ARARs is in Appendix C.

Groundwater. Potential groundwater ARARs for conditions at, or stemming from activities at, BAAP include the SDWA, RCRA, and Wisconsin Drinking Water Rules (WAC, 1989) and Groundwater Quality Standards (WAC, 1990). The SDWA establishes both MCLs and MCLGs. MCLs are enforceable standards that apply to specified contaminants that USEPA has determined to have an adverse effect on human health above certain levels. MCLs are set as close as feasible to MCLGs. (Feasibility in this determination takes both technology and cost considerations into account.) MCLGs are nonenforceable, health-based goals that have been established at levels at which no known or anticipated adverse effects on the health of persons occur and which will allow an adequate margin of safety. Because these values are based on no known or anticipated health effects, these values are considered to be protective of human health under nearly all circumstances. Under the NCP (40 CFR 300), MCLGs with values above zero that are established under the SDWA will generally be used as cleanup levels for groundwater that is a current or potential source of drinking water. This requirement depends upon an evaluation of the circumstances of the release.

In addition, federal nonpromulgated advisories or guidance must be considered when ARARs for specific contaminants are not available. The TBCs include USEPA Health Advisories (HAs), USEPA RfDs, and USEPA Carcinogen Assessment Group Carcinogen Slope Factors (CSFs). The USEPA developed two guidance documents for assessing risks and determining contaminant transport and fate. The Acceptable Intake - Subchronic health assessment documents provide values developed for the RfDs and Health Effects Assessments for noncarcinogenic compounds.

Wisconsin groundwater quality standards apply to virtually all facilities, activities, and practices regulated by the state which may affect groundwater quality. Chapter NR 140 encompasses the following relevant areas:

1. It establishes two separate numerical standards for a wide group of pollutants. These are enforcement standards (ESs) and preventive action limits (PALs) (Chapter NR 140.10 and Chapter NR 140.12).

2. It specifies scientifically valid procedures for determining if numerical standards have been attained or exceeded (Chapter NR 140.14).

3. It specifies procedures for establishing points of standards compliance (WAC, Chapter NR 140.22).

4. It establishes sets of ranges of responses required if a groundwater standard (PAL or ES is attained or exceeded [Chapters NR 140.24, NR 140.26, and NR 140.27]).

Under Chapter NR 140, two separate standards, an ES and a PAL, were developed for public health (NR 140.10) and public welfare (NR 140.12). ESs are set at concentrations greater than PALs.

PALs are developed by using a percentage of ESs (i.e., 10 percent for carcinogenic compounds and 20 percent for noncarcinogenic compounds), and must be achieved if technically and economically feasible. The feasibility of complying with a PAL is determined on a case-by-case basis.

According to NR 140.22, when designing a facility, ESs and PALs can be applied at the following locations:

- any point of current groundwater use

- any point beyond the boundary of the property on which the facility, practice, or activity is located

- any point within the property boundaries beyond the three-dimensional design management zone if one is established by WDNR at each facility, practice, or activity

For spills, discharges, and other remedial response actions, the point of standards application is every point at which groundwater is monitored to determine if a PAL or ES has been attained or exceeded.

Sections NR 140.24, and NR 140.26 delineate the range of remedial responses required after verification that PALs and ESs are exceeded, respectively. In both sections, notification and evaluation criteria are presented. The difference in response requirements between NR 140.24 and NR 140.26 mainly are that WDNR, under NR 140.24, has the latitude to require no action, additional sampling, or further testing/study actions if a PAL is exceeded or attained. Under NR 140.24, the WDNR may also require the following responses:

- Revise the operational procedures at the facility, practice, or activity.

- Change the design or construction of the facility, practice, or activity.

- Develop an alternate method of waste treatment or disposal.

- Prohibit or close and abandon a facility, practice, or activity.

- Conduct a remedial action to renovate or restore groundwater quality.

- Revise rules or criteria on facility design, location, or management practices.

Under Chapter NR 140.26, if a determination is made that an ES is violated at a point of compliance, WDNR requires one of the above actions with no exceptions (i.e., no provision for a no action response).

Surface Water. Surface water at BAAP is protected by federal and state regulations, including federal CWA Ambient Water Quality Criteria (AWQC), Wisconsin Water

Quality Standards, and Wisconsin Water Pollution Control Regulations. Wisconsin regulations that govern surface water include:

- Chapter NR 102, Water Quality Standards for Wisconsin Surface Waters
- Chapter NR 103, Water Quality Standards for Wetlands
- Chapter NR 105, Surface Water Quality Criteria for Toxic Substances
- Chapter NR 106, Procedures for Calculating Water Quality-Based Effluent Limitations for Toxic Substances Discharged to Surface Waters
- Chapter NR 220, Water Pollution Control Regulations; Application for Discharge Permits

Surface water cleanup goals should generally be attained at the point or points where the release enters the surface water.

<u>Sediments</u>. Regulatory values establishing acceptable concentrations of contaminants in sediments have not been promulgated at the federal level. For state-level regulations, see the discussion below for soil.

<u>Soil</u>. At the federal level, there have been no specific, promulgated standards addressing acceptable soil contamination concentrations. Current methodology involves development of a cleanup level based on public health or ecological risk considerations. The USEPA has established an interim soil cleanup level for PB that is protective of public health. The interim guidance recommends a cleanup level for total lead of 500 to 1,000 milligrams per kilogram (mg/kg). Site-specific conditions may warrant levels lower than 500 mg/kg, based on an exposure assessment.

The State of Wisconsin has proposed soil remediation standards (NR 720). The soil standards contain guidance for developing soil cleanup levels based on demonstrations that: (1) show soil contaminant levels would not be expected to impact the NR 140 groundwater standards, and (2) the cleanup levels are protective of human health. The standards are also applicable to sediments.

Air. Site remediation activities must comply with applicable or relevant and appropriate federal and state air quality emission standards. The potential chemical-specific ARARs for air are listed in Table 2-3. An expanded discussion of each of these rules is provided in Appendix A of the Final RI Report (ABB-ES, 1993a).

Federal Requirements. The federal air emission standards include the NAAQS (40 CFR Part 50); New Source Performance Standards, (40 CFR 60); and National Emission Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR 61).

National Ambient Air Quality Standards. The NAAQSs include both primary and secondary standards. The primary standards are intended to protect public health; secondary standards are set at levels to protect welfare, including wildlife, recreation, and economic values. NAAQS do not apply directly to source-specific emissions limitations. Instead, the state translates the emission limitations into source-specific limitations through SIPs. Upon USEPA approval, the SIP becomes both federally enforceable and a potential federal ARAR. The SIP for Wisconsin is composed of the state air regulations, and is currently under review.

New Source Performance Standards. New Source Performance Standards (NSPSs) establish emission limits for a number of different pollutants for certain classes of new stationary sources. The list of pollutants includes limits for fluorides, sulfuric acid mist, and total reduced sulfur. These provisions are generally not applicable to cleanup actions. However, if a facility is a new source subject to a NSPS (such as an incinerator), the requirement may be applicable. If the pollutants emitted and the technology employed is similar to the pollutant and source category regulated, the NSPS may be considered relevant and appropriate.

National Emission Standards for Hazardous Air Pollutants. NESHAPs are particulate emission limits for pollutants according to source type (i.e., industrial categories) that emit the hazardous pollutant. NESHAPS have been promulgated for beryllium (BE) and mercury (HG) from specific sources. NESHAPS are not generally potential ARARs because the sites rarely contain a specific regulated source and the standards of control are intended for the specific type of source regulated and not all sources of that pollutant. Part of a NESHAP may be relevant and appropriate in instances where a regulated emission is produced by other than the regulated source.

Hazardous Air Pollutants. The Clean Air Act Amendments of 1990 established the requirement to promulgate new source-specific emissions standards for sources of 189 listed hazardous air pollutants. These standards must reflect the maximum achievable control technology considering cost, energy requirements, and other impacts. The tonnage of potential hazardous air pollutants to be emitted in a year determine whether or not a source will be designated as a major source and will therefore be subject to the Clean Air Act Amendments permitting requirements.

State Requirements. State chemical-specific air emissions standards are established by four regulations: (1) General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (Chapter NR 404); (2) Particulate and Sulfur Emissions Rules; Control of Particulate Emissions (Chapter NR 415); (3) Organic Compound Emissions Rules (Chapter NR 419); and (4) Hazardous Air Pollutants Emissions Standards (Chapter NR 445).

The General and Portable Sources Air Pollution Control Rules. Ambient Air Quality Standards are comparable to the NAAQS primary and secondary ambient air quality standards. Standards are established for sulfur oxides, suspended particulates, carbon monoxide, ozone, nitrogen dioxide, PB and particulate matter with an aerodynamic diameter less than or equal to a nominal concentration of respirable dust particles ($PM_{10}$). The primary air standard is the level of air quality that provides protection for public health with an adequate margin of safety. The secondary air standard is the level of air quality that may be necessary to protect public welfare from unknown or anticipated adverse effects.

The Particulate and Sulfur Emissions Rules. Control of particulate emissions applies to all air contaminant sources and requires precautions to be taken to prevent particulate matter from becoming airborne. Examples of precautions include, but are not limited to, use of water or chemicals for control of dust, application of plastic covering on material stockpiles and surfaces that could create airborne dust, or covering or securing of materials likely to become airborne while being moved on public roads.

The Organic Compound Emissions Rules. These rules require that reasonable precautions be taken when handling organic compounds to prevent spillage or escape or emission of organic compounds, solvents, or mixtures. In addition, no person may dispose of more than 5.7 liters of any liquid

volatile organic compound (VOC) waste, or any liquid, semisolid, or solid waste materials containing more than 5.7 liters (1.5 gallons) of any VOC, in any one day from a facility in a manner that would permit evaporation into the ambient air during the ozone season. This includes but is not limited to the disposal of VOCs that must be removed from VOC-control devices so as to maintain the devices at the required operating efficiency.

The Hazardous Air Pollutants Emissions Standards. These standards establish air contaminant emission concentrations as percentages of threshold limit values established by the American Conference of Governmental Industrial Hygienists. Emission standards are listed for each contaminant for 24- and 1-hour averaging periods. The standards may be applicable to remedial activities that involve treatment by a process which generates hazardous air contaminant emissions. Some emission rates that may be considered at BAAP are listed in Appendix A of the Final RI Report (ABB-ES, 1993a).

## 2.7 Identification of Action-Specific ARARs.

Action-specific ARARs provide a basis for screening remedial technologies, developing remedial alternatives, and assessing the feasibility and effectiveness of each remedial alternative retained for detailed evaluation. Action-specific ARARs, unlike location- and chemical-specific ARARs, are usually technology- or activity-based limitations that direct how remedial actions are conducted. Table 2-5 summarizes the potential action-specific requirements associated with each of the remedial alternatives that may be considered at BAAP.

# 3.0 PROPELLANT BURNING GROUND

This section first summarizes the Propellant Burning Ground background and history, geology and groundwater characterization, contamination assessment, and baseline risk assessment described in Section 6 of the Final RI Report (ABB-ES, 1993a). Then, based on current and potential future risks to human health and ecological receptors at the site, this section develops the remedial action objectives and alternatives necessary to address site contamination. This section concludes with the screening of remedial alternatives. Those alternatives retained after the screening process are further evaluated in the detailed analysis presented in Section 9.

The Final RI Report (ABB-ES, 1993a) concluded that groundwater contamination at the Settling Ponds and Spoils Disposal Area is associated with source areas at the Propellant Burning Ground. Consequently, groundwater contamination at the Settling Ponds and Spoils Disposal Area will be addressed in conjunction with Propellant Burning Ground groundwater in this section. Section 6 of this report addresses only soil contamination at the Settling Ponds and Spoils Disposal Area.

## 3.1 SITE BACKGROUND AND HISTORY

The Propellant Burning Ground is located in the southwestern portion of BAAP and is made up of several distinct areas (Figure 3-1) including the Contaminated Waste Area, Racetrack/Burning Ground, the 1949 Pit Area, and Landfill 1, which are no longer active, but have been in existence and used since sometime after 1942. The Contaminated Waste Area and 1949 Pit Area combined are approximately 6 acres in size and currently contain three former waste disposal pits (designated WP-1, WP-2, and WP-3), a large open area used for burning propellant-contaminated materials (i.e., the Old Burn Area), and an area adjacent and west of the Contaminated Waste Area designated as the 1949 Pit. Landfill 1, located approximately 400 feet east of the Contaminated Waste Area, was a waste disposal area reported to be approximately 300 by 200 feet in area. The entire Propellant Burning Ground area encompasses approximately 80 acres (Sarko, 1981). The surface area of the existing pits, pads, and the open-burning area (i.e., the areas shaded in Figure 3-1 minus the 1949 Pit and Landfill 1) in the Propellant Burning Ground is approximately 35,900 square feet, or 0.82 acre.

The Racetrack/Burning Ground, located south of the Contaminated Waste Area, is an oval gravel road. Currently, two concrete Burning Pads (designated BP-1 and BP-2) are located on the western side of the racetrack. BP-1 is currently active and contains a metal burning dish used to burn small amounts of waste propellant. BP-2 is currently inactive. Former facilities located at the Racetrack/Burning Ground include the Burning Plates on the eastern side of the racetrack, and three inactive refuse burning pits (designated RP-1, RP-2, and RP-3) southeast of the racetrack. A review of historical aerial photographs indicates this area was constructed sometime between 1949 and 1955 (ABB-ES, 1993a). The 1955 aerial photographs show the constructed Racetrack, Burning Pads, and Burning Plate areas.

The Burning Ground/Racetrack Area contains an active decontamination oven used to remove remnants of propellant from metal objects scheduled for maintenance, salvage, or scrap (Warzyn, 1982b). The decontamination oven is located approximately midway between the northern and southern areas of the Propellant Burning Ground.

The Propellant Burning Ground is operated by the BAAP maintenance department. This area originally was regulated under WAC, Chapter NR 181. In 1978, License No. 2814 was issued by the state for thermal treatment of wastes in this unit. In accordance with WAC, Chapter NR 181, WDNR issued a RCRA interim status license on April 2, 1986, which remains in effect at this time (Didier, 1987). WAC Chapter NR 181 has since been replaced by the WAC NR 600 series.

According to the MEP, open burning on bare ground was carried out to dispose of waste explosives and propellants and explosive-contaminated wastes from plant start-up until January 1983 (Tsai et al., 1988). In 1983, procedures for open burning of propellants and explosives were modified to meet the January 25, 1983 requirement prohibiting open burning on bare ground. Modifications included construction of a steel burning dish and decontamination oven.

Contaminated Waste Area. The Contaminated Waste Area is located approximately 500 feet north and slightly east of the Racetrack Area (see Figure 3-1). It previously consisted of three large open pits (each approximately 40 feet in diameter and 12 to 15 feet deep) and the Old Burn Area. This area became active sometime between 1942 and 1949, but is now inactive. The pits were last used in January 1983; it is not known when the Old Burn Area was last used. Organic solvents, propellant-contaminated wastes, and lumber were formerly burned in the pits. Reportedly, these Waste Pits were also used for the dumping/burning of process

chemicals (Kearny, 1987). The Installation Assessment Report stated that as much as 500 gallons per week of a mixture of 2,4-dinitrotoluene (24DNT), 26DNT, di-n-butyl phthalate (DNBP), diphenylamine (DPA), C6H6, and other chemicals may have been dumped and/or burned in these pits from 1966 to 1977 (USATHAMA, 1977). One pit, WP-1, has since been filled with a silty clay soil and graded to conform with existing area topography. Boring data indicate that about 8 to 10 feet of soil fill exists over the waste material in WP-1. WP-2 and WP-3 currently exist as open depressions, each approximately 40 feet in diameter by 12 feet deep.

According to the MEP, solvent and solvent-containing solid wastes were burned at the Propellant Burning Ground along with propellants and propellant explosive-contaminated wastes (Tsai et al., 1988). The most likely locations of solvent disposal and burning are the three Waste Pits and three Refuse Pits in the Contaminated Waste Area and Racetrack Area, respectively. It is also likely that solvents were burned or disposed of in the Old Burn Area in the Contaminated Waste Area, and possibly in the Burning Pads and Burning Plate areas (especially before installation of the current concrete and steel burning apparatus). TRCLE was used from 1966 to 1974 and was burned with lumber in the area of the three Waste Pits (U.S. Army Environmental Hygiene Agency [USAEHA], 1985).

Further investigation into solvent disposal activities as described by the Installation Assessment Report and the MEP indicates that a listed hazardous waste was disposed of in the waste pits at the Contaminated Waste Area. A Point Source Pollution Engineering Study prepared for BAAP contains a description of a process where "Single Base" additives are extracted from propellant using a solution of C6H6 and ethyl acetate (Olin Corporation, 1984). The exhausted extraction solution is pumped to a still where a large percentage of the C6H6 is recovered. Still bottoms were removed for disposal at the "burning ground." Because the percentage (by volume) of C6H6 in the extraction solution was greater than 10 percent, the C6H6 waste is a listed hazardous waste from non-specific sources (i.e., F005) per 40 CFR Part 261.31.

Other than what is shown in historical aerial photographs of the Contaminated Waste Area, little is known of disposal practices in the 1949 Pit. Evidence of activity as well as many unidentified objects are visible in the photographs of the pit area. The pit has since been backfilled with soil.

<u>Racetrack/Burning Ground Area</u>. Historical aerial photographs indicate that the Racetrack Area and associated Burning Pads and Plates and Refuse Pits were not

constructed or active until after November 1949. The two concrete Burning Pads in the Racetrack Area measure approximately 24 by 30 feet and were constructed after June 1978 and before 1986. Burning Pad 1 contains a steel burning dish, 42 inches in diameter. Installed in 1983, it is currently used to burn waste propellants. Burning Pad 2 is not currently in use and does not have a burning dish. Existing literature indicates that up to 50 pounds of nonspecification propellant is burned at a time in the burning dish at Burning Pad 1 (Tsai et al., 1988). Some propellants, particularly those of rocket paste formulations, contain PB compounds. Currently, ash and residuals generated in the Burning Pad Area are placed in drums and stored in the BAAP permitted hazardous waste storage area while awaiting characterization for disposal.

Before the concrete Burning Pads were constructed and the burning dish installed (before 1983) in this area, powder and waste material were burned directly on the ground. Materials burned on the ground in this area included nitrocellulose (NC), ball powder, nitroglycerine (NG)-containing compounds, and waste propellant paste. In addition, carbon tetrachloride (CCL4) might have been burned with propellants during the periods 1942-45, 1951-56, and 1966-71 (USAEHA, 1985). A maximum of 100 pounds of propellant-containing wastes, at a 3-inch maximum depth, was burned at one time (Kearny, 1987). As a result, PB and propellant residues were detected in soil samples collected from this area during previous investigations.

The eastern edge of the oval Racetrack Area, referred to as the Burning Plates Area, was used to dry and burn quantities of wet NC on open steel, gas-fired grills.

Each of the three shallow Refuse Pits on the southern edge of the burning ground is reported to have been 15 to 30 feet in diameter. The pits were used for open burning of empty containers in which propellant materials were delivered and stored (Kearny, 1987). Organic solvents (e.g., CCL4 and TRCLE) reportedly were burned in these Refuse Pits in conjunction with contaminated refuse. It has been reported that as part of the interim waste measure to clean out the Rocket Paste Area outfall ditch, each Refuse Pit was filled with propellant-contaminated soils collected from the Rocket Paste Area outfall ditch and covered with a polyethylene cap (Tsai et al., 1988). In September 1985, visibly contaminated soil in these pits was removed, including the soils 3 feet below the visible contamination. Two hundred twenty-two (222) 55-gallon drums of soil (approximately 133,000 pounds) were excavated from these pits as an interim remedial action. This soil is currently held in a magazine building. The Refuse Pits were refilled with clean soil and reseeded (Fordham, 1987). Review of historical aerial photographs indicate that it is likely that the use

of Refuse Pits for burning and disposal of solvent-contaminated waste and propellants was of limited duration.

The decontamination oven is located approximately halfway between the southern racetrack and the northern Contaminated Waste Area. The oven is approximately 20 by 60 feet in size, and is used to decontaminate drums, containers, and/or equipment that could contain explosive or propellant materials. These materials are decontaminated in the oven by flashing under controlled temperatures (up to 700 degrees Fahrenheit) before being taken to the shop for maintenance or to the scrap yard for salvage or sale.

Landfill 1. Landfill 1 was reportedly used between 1942 and 1959 (Tsai et al., 1988). Based on aerial photographs, this area was originally excavated between 1944 and November 1949. Approximately 600,000 cubic feet of solid waste was reportedly disposed of in the landfill. The types of waste included structural timbers, asphalt shingles, cardboard, office refuse, and other unknown wastes generated from various BAAP unit operations. During ABB-ES' site reconnaissance in August 1988, pipe insulation material was observed in rubble on the ground surface at the site. This material, tested by Olin in January 1990, was found to be asbestos (Olin, 1990). The MEP reported that in addition to receiving wastes for disposal, open burning of propellants, extraction wastes (e.g., dinitrotoluene (DNTs), DNBP, and DPA), C6H6, and black powder was conducted at the landfill. Both hazardous and nonhazardous wastes are believed to be buried in Landfill 1 (Tsai et al., 1988).

Aerial photographs show Landfill 1 in sufficient detail to estimate the size and depth of the excavation. The maximum estimated size of the excavation during its operation was approximately 300 to 350 feet long by 100 feet wide. The maximum estimated depth was approximately 12 to 15 feet. Aerial photographs indicate the landfill was probably about half the width reported by Kearny, and that maximum capacity was 400,000 to 500,000 cubic feet (Kearny, 1987). Because the pit was cut as an oblong and circular depression, it is likely that fill volume was substantially smaller than reported in the MEP. Aerial photographs show some mounds of material apparently end-dumped in rows along the northern side of the pit area. This material appears to correspond to the demolition debris observed during the ABB-ES site reconnaissance of August 1988. In addition, these photographs show Landfill 1 filled and covered in 1974. Boring data indicate that less than 1 foot of sandy fill exists over the waste material in Landfill 1.

## 3.2 GEOLOGY AND GROUNDWATER CHARACTERIZATION

The geologic and hydrogeologic interpretations of the Propellant Burning Ground are based on data presented in the Final RI Report (ABB-ES, 1993a).

### 3.2.1 Surface Water Hydrology

Topographic relief in this area is largely dominated by the Johnstown terminal moraine ridge and the outwash plain west of the moraine. The morainal ridge, rising as much as 60 to 80 feet above the surrounding area, is oriented roughly north-south in the vicinity of the Propellant Burning Ground. West of the morainal ridge, the ground surface slopes downward at 5 to 10 percent to the outwash plain, where slopes decrease to approximately 2 percent or less. The Propellant Burning Ground is located on the westward-sloping flank of the moraine.

Surface water runoff in the Propellant Burning Ground is restricted to ephemeral flows of spring runoff following snowmelt. Much surface runoff that does occur is captured in isolated depressions and then evaporates or infiltrates. The morainal ridge forms a surface water divide forcing a portion of runoff to flow westward toward the outwash plain (where it may drain into Final Creek), and the remainder to flow eastward into poorly defined drainage patterns. Final Creek routes surface water runoff and wastewater from the Wastewater Treatment Plant (WWTP) to the east for discharge into the Settling Ponds (see Figure 1-2).

### 3.2.2 Geology

Soil borings and monitoring wells installed at the Propellant Burning Ground encountered soil conditions consistent with those observed at other BAAP locations. These include approximately 250 feet of unconsolidated soil deposited in association with the maximum advance of the Green Bay Lobe Glacier (Alden, 1918; and Thwaites, 1958).

Generally, the stratigraphic sequence includes a veneer of fine-grained silt underlain by variably textured sands and gravels with occasional cobble and boulder zones. At an approximate elevation of 700 to 725 feet MSL, a continuous 10- to 20-foot-thick cobble and gravel layer (oriented north-south) was encountered. This coarse layer appears to be located west of and parallel to the axis of the terminal moraine. Underlying the cobble and gravel layer are additional deposits of variably textured sands and gravel. Immediately above bedrock, another gravel cobble layer was

encountered. Finally, sandstone bedrock belonging to the Eau Claire Formation was encountered at an approximate elevation of 600 to 620 feet MSL. The bedrock appears to have a relatively flat surface with a gentle slope to the southeast (see Figure 1-3).

Geologic cross sections depicting generalized stratigraphic relationships among the various soil units at the site are oriented in Figure 3-2 and shown in Figures 3-3, 3-4, and 3-5. The following paragraphs describe in more detail the soil units encountered at the site and their impact on the groundwater flow system in this area.

Immediately below the ground surface under both the Propellant Burning Ground and the Settling Ponds and Spoils Disposal Area is a 5- to 10-foot-thick veneer of loess. This fine-grained unit consists of windblown silt and clay. Logs of borings drilled in this area generally describe this unit as a cohesive silt and clay with some interbedded fine sand at depth. It appears likely that, during excavation of the pits, loess materials were stripped from the Burning Pits and Waste Pits.

Variably textured sands and gravels were encountered beneath the surficial loess materials. These were typically characterized as ranging from brown, fine-to-coarse sand with a trace of silt and fine gravel, to light brown, medium-to-coarse gravel with little sand. No substantial silty or clayey tills were encountered in the borings installed during 1991 at the Propellant Burning Ground.

A continuous, nearly flat-lying, 10- to 20-foot-thick coarse-grained cobble and gravel layer was encountered at an approximate elevation of 700 to 725 feet MSL west of the terminal moraine in the Propellant Burning Ground. The texture and location of this coarse-grained unit suggests it might represent erosion and initial outwash deposition during the period of maximum glacial advance. This coarse-grained unit is laterally extensive along the western boundary of the terminal moraine and could extend to the Baraboo Hills north of BAAP parallel to the terminal moraine. Boring logs from wells in the region suggest this unit could extend to the Town of Prairie du Sac south of BAAP. Numerous, very dense cobble and boulder zones were encountered at higher elevations within the unsaturated zone in borings drilled near the axis of the morainal ridge.

Bedrock was encountered in soil boring PBB-89-10 (240 feet), BAAP Production Well No. 5 (260 feet), and SPN-91-03D (225 feet) (see Figure 3-2). The bedrock was described as a white to light brown, fine-to-medium sandstone, which is very dense and poorly cemented near its upper surface. However, substantial siltstone and shale

units were also observed with depth. The bedrock likely belongs to the Eau Claire Formation (Upper Cambrian). The bedrock surface elevation is approximately 615 to 620 feet MSL at the Propellant Burning Ground and appears to dip gently downward to the southeast.

### 3.2.3 Site Hydrogeology

Hydrogeologic conditions at the Propellant Burning Ground are mainly controlled by geologic conditions underlying the area. In addition, this area is also influenced by the elevated water level in the Lake Wisconsin Reservoir and the lower water level below the WP&L dam. The locations of monitoring wells, referenced in the following paragraphs, are shown in Figure 3-6. For those wells identified with the letter prefix (e.g., PBM and PBN), M indicates a single monitoring well, and N indicates a group of nested wells. The number (e.g., 89) indicates the year the well was installed (i.e., 1989). Nested well screen designations A, B, C, and D represent progressively deeper installation intervals. Well designations without a letter suffix (e.g., PBM-89-07) or a well designation with an A suffix (e.g., PBN-89-01A) represent water table wells. The B suffix (e.g., PBN-89-01B) represents an intermediate level well, while the C and D suffixes represent progressively deeper well-screen intervals.

A 5- to 10-foot-thick layer of silty clayey loess underlies the topsoil in this area. Laboratory permeability tests conducted on soil samples collected from this unit indicate its low permeability (Warzyn, 1982a). Laboratory permeabilities of $4x10^{-7}$ and $5x10^{-6}$ centimeters per second (cm/sec), respectively, were reported for subsurface soil samples from PBN-82-01A and PBN-82-02A, collected at depths of 4 to 6 feet and 2.5 to 4.5 feet. As described in Subsection 1.3.3.4, the near-surface fine-grained loess unit restricts the deep infiltration of precipitation to approximately 5 to 9 inches per year. Below the loess, a thick sequence of sand and gravel comprises a considerable vadose zone through which groundwater percolates before recharging the water table. The water table is located as deep as 110 to 120 feet below ground surface (bgs) at Landfill 1. As the ground surface slopes downward to the southeast near the Wisconsin River, depth to the water table decreases to approximately 40 feet bgs.

The water table at the Propellant Burning Ground occurs in coarse-grained sands and gravels, resulting in relatively small vertical gradients and uniform horizontal gradients across the water table. Vertical gradients calculated at various well nests at the Propellant Burning Ground are illustrated in Figures 3-3, 3-4, and 3-5. Localized variations in the vertical gradients likely reflect changes in hydraulic

conductivity and flow velocities in the groundwater flow system. Several well nests have shown very small (0.0002 to 0.0003 foot per foot [ft/ft]) downward gradients from the upper portion of the sand and gravel aquifer into the gravel/cobble zone (i.e., PBN-85-03A/PBN-89-03B, PBN-85-04A/PBN-89-04B, PBN-89-12A/PBN-89-12B, and S1147/SPN-89-03B). Several other well nests have shown very small (0.0006 to 0.005 ft/ft) upward gradients into the gravel/cobble zone from the lower portion of the sand and gravel aquifer (i.e., PBN-89-10B/PBN-89-10C and PBN-89-03B/PBN-89-03C). This gradient pattern could possibly reflect the gravel zone acting as a hydraulic drain and inducing small vertical flow components that are upward from below and downward from above in the less permeable sands. This condition is not reflected in all well nests; well nest PBN-89-12B/PBN-89-12C has a downward vertical gradient indicating flow out of the gravel/cobble zone into a deeper portion of the aquifer.

Figure 3-7, an interpreted water table contour map for the Propellant Burning Ground, indicates that horizontal flow gradients are relatively small and uniform (i.e., 0.0013 to 0.0015 ft/ft) across much of the area, with a total head drop of 10 to 11 feet from the northern Propellant Burning Ground to the installation boundary. This condition is typical of sand and gravel aquifers where highly permeable soil is not capable of supporting strong gradients. Generally, groundwater flow is south, with a southwesterly flow component in the southeastern portion of the Settling Ponds and Spoils Disposal Area and a minor southeasterly flow component in the northern portion of the Propellant Burning Ground.

The transition of groundwater flow from south-southeasterly in the western portion of the Propellant Burning Ground to south-southwesterly in the eastern portion of the Settling Ponds and Spoils Disposal Area apparently reflects the influence of the elevated water level in the Lake Wisconsin Reservoir east of BAAP. The WP&L dam, located approximately 1.5 miles south of the BAAP boundary, has an approximate 40-foot head difference across the dam. The elevated water level in the reservoir forms a gradient that could result in discharge to groundwater from the Lake Wisconsin Reservoir in this area. This occurs near the reservoir where the groundwater elevation in the aquifer is lower than the reservoir elevation (i.e., 774 feet MSL). This condition occurs near the eastern end of the Settling Ponds and Spoils Disposal Area.

Hydraulic conductivity tests (in situ rising-head slug tests) were completed by ABB-ES in 29 wells at the Propellant Burning Ground. The tests focused on the shallow and deep monitoring wells, and indicated a hydraulic conductivity range of

$1x10^{-3}$ to $2x10^{-1}$ cm/sec, with a median value of $4x10^{-2}$ cm/sec. These results correlate well with aquifer test results from Boundary Control Wells No. 2 (BCW-2), performed by Olin, and No. 3 (BCW-3), performed by ABB-ES, which indicate a conductivity of $2x10^{-2}$ to $8.5x10^{-2}$ cm/sec (see Final RI Report, [ABB-ES, 1993a]), as well as the specific capacity test performed on BAAP Production Well No. 4, which indicated a hydraulic conductivity of $5x10^{-2}$ cm/sec.

Hydraulic conductivity tests performed in wells screened in the gravel/cobble layer (encountered at an approximate elevation of 700 to 725 feet MSL in borings located just west of the axis of the terminal moraine) have shown evidence of a high permeability zone. The higher hydraulic conductivity is illustrated by test results at wells LON-89-02B (K = $4x10^{-2}$ cm/sec), PBN-89-10B (K = $2x10^{-1}$ cm/sec), and PBN-89-01B (K = $3x10^{-2}$ cm/sec). The horizontal gradient along this unit is relatively uniform at 0.0012 to 0.0015 ft/ft, agreeing with the data from the water table wells in this area. Given the higher permeabilities and similar horizontal gradients, it is possible that groundwater flow velocities and discharge rates are higher in the gravel/cobble layer than in the adjacent sandy soil. As shown in Figure 3-3, vertical gradients often indicate flow into the gravel/cobble layer from above and below but the magnitude of these gradients is probably not sufficient to significantly influence groundwater flow in the aquifer.

Groundwater flow velocity calculations were performed for the Propellant Burning Ground and the Settling Ponds and Spoils Disposal Area (ABB-ES, 1993a). The calculations indicate a velocity range of 30 to 460 feet per year (ft/yr), with an estimated median velocity on the order of 330 ft/yr. The higher velocities are most likely associated with a coarse gravel/cobble zone while the lower velocities reflect conditions in finer grained sand zones. The velocity analyses assume that areas with higher transmissivities generally have a somewhat lower hydraulic gradient. This condition occurs naturally because the higher the transmissivity, the lower the resistance to flow and the lower the hydraulic gradient that can be supported.

Two hydrogeologic models were constructed to assist in the interpretation of groundwater flow in the vicinity of the Propellant Burning Ground and surrounding area. A general box model was developed to assess the influence of the sand and gravel layers on vertical groundwater flow. This model helped establish the number of layers needed to simulate groundwater flow in a site-specific Propellant Burning Ground model. Boundary conditions for both models were based upon the BAAP regional groundwater flow model. The site-specific Propellant Burning Ground model was developed to focus on groundwater flow at the Propellant Burning

Ground and interim remedial measure (IRM) extraction wells. Details of the models are presented in the Final RI Report (ABB-ES, 1993a).

The results of the box model indicate that the influence of an extraction well, screened in the top sand and gravel layers and pumping at 100 gallons per minute (gpm), extended through the high hydraulic conductivity gravel zone and into the lower hydraulic conductivity underlying sand layers. These results indicate that groundwater flow, particularly to extraction wells, is not completely dominated by the presence of coarse-grained gravel layers. This conclusion is supported by the results of the box model sensitivity analysis and the BCW-3 aquifer test results (ABB-ES, 1993a).

The Propellant Burning Ground model indicates that the existing IRM extraction wells are only partially effective at capturing the Propellant Burning Ground groundwater contaminant plume. Some contaminated groundwater may be flowing past the IRM extraction wells (ABB-ES, 1993d).

## 3.3 Contamination Assessment Summary

The soil and groundwater contamination assessment summaries are based on data presented in the Final RI report (ABB-ES, 1993a).

### 3.3.1 Contamination Assessment - Surface Soils

Surface soil samples were collected for laboratory analysis from 118 locations within three separate areas at the Propellant Burning Ground. The samples were collected to characterize the distribution of surface soil contamination in and around the former burning areas. Forty-one samples (i.e., PBS-91-01 through PBS-91-40 and PBS-91-49) were collected from the Burning Pads area. Sixty-nine samples (i.e., PBS-91-50 through PBS-91-118) were collected from a larger grid that includes the Racetrack and Burning Plates area. PBS-91-109 through PBS-91-118 were collected with hand augers at depths of approximately 3 feet bgs to characterize the vertical extent of contamination in the Racetrack and former Burning Plates area. Finally, eight samples (i.e., PBS-91-41 through PBS-91-48) were collected from the Contaminated Waste Area. No surface soil samples were collected from around the decontamination oven.

Surface soil samples were analyzed for VOCs, semivolatile organic compounds (SVOCs) (including 24DNT and 26DNT), and priority pollutant metals. Selected samples were also tested for leaching potential, using Toxicity Characteristic Leaching Procedure (TCLP) analysis for the metals, cadmium (CD), chromium (CR), HG, and PB.

The primary chemicals found in surface soil include metals (i.e., CR, copper [CU], PB, and zinc [ZN]) at concentrations in excess of background and organic compounds (i.e., 24DNT and 26DNT).

The distribution of VOCs, SVOCs, and DNTs in surface soil samples is shown in Figure 3-8. Compounds detected include C6H6, n-nitrosodiphenylamine (NNDPA), and 24DNT. The VOCs CCL4, TRCLE, and C6H6 were reportedly disposed of at the Propellant Burning Ground by dumping or open burning. Of these, only C6H6 was detected in the surface soil samples. This distribution probably results from a combination of transport processes and backfilling of the Contaminated Waste Area and Waste Pits with clean soil. Volatilization to the atmosphere and downward migration in the soil column as a result of infiltrating precipitation are expected to be the predominant fates of VOCs disposed of at the surface. Based on detected concentrations of VOCs and the processes discussed previously, it appears that surface soil at the Propellant Burning Ground does not currently represent an active contamination source of VOCs to the atmosphere or the underlying soil column and groundwater.

The primary SVOCs detected in surface soils are 24DNT and 26DNT. Evidence from subsurface and groundwater analyses suggests the migration of DNTs to groundwater; however, the migration is very localized. Although DNTs were present in high concentrations in surface soil at the Burning Pads, other sources for DNTs found in groundwater have been identified. These additional sources are discussed in Subsection 3.3.2.

Although surface soil sampling was not conducted in the center of Waste Pits WP-2 and WP-3, high concentrations of VOCs and/or DNTs are suspected in these locations. Documented historical disposal practices and boring data from WP-1 support this assumption. A discussion of boring data from the Waste Pits is presented in Subsection 3.3.2.

The metals PB, CU, ZN, and HG detected at the Propellant Burning Ground are present in the highest concentrations in the Burning Pads Area. This area was

formerly used for open burning of waste propellant and by-products. Rocket paste contained as much as 1.2 percent (by weight) each of PB salicylate and PB ethylhexoate (Piercy, 1977). Open burning, reportedly conducted on bare soil before installation of the concrete Burning Pads in 1983, appears to have resulted in contamination of surface soil in the area with the observed high levels of PB. High concentrations of PB are also present in the Contaminated Waste Area, where open burning outside the Waste Pits might have occurred at one time. The distribution of PB in surface soil at the Racetrack and in the Contaminated Waste Area is shown in Figures 3-9 and 3-10, respectively. Arsenic (AS), detected in surface soils, is not likely to be associated with propellant and by-product burning, but may be attributable to ash from AS-treated wood or treated packing material burned in the Waste Pits.

TCLP test results indicate that surface soil from some areas of the Propellant Burning Ground (especially the Burning Pads Area) would be classified as RCRA hazardous waste according to TCLP criteria for PB. The distribution of surface soil exceeding the TCLP criteria for PB at the Racetrack and in the Contaminated Waste Area is shown in Figures 3-11 and 3-12, respectively. Despite the apparent low mobility of the detected metals, these may represent a potential long-term source of leachable PB.

### 3.3.2 Contamination Assessment - Subsurface Soils

A total of 134 subsurface soil samples were collected for chemical analysis from test pits PBT-90-01 through PBT-90-08 and soil borings PBB-90-01, PBB-90-02, and PBB-91-01 through PBB-91-07 (Figure 3-13). The eight test pits excavated within the area of the 1949 Pit revealed buried cast iron pipes, long steel supporting rods, metal sheeting, one crushed drum (approximately 40-gallon capacity), and a small amount of oily contaminated soil. Soil borings PBB-90-01 and PBB-90-02 were drilled through the 1949 Pit. Soil borings PBB-91-01 through PBB-91-07 were drilled through or adjacent to Refuse Pits 1, 2, 3, Waste Pits 3, 2, 1, and the Old Burn Area, respectively. Subsurface soil samples were analyzed for VOCs, SVOCs (including 24DNT, 26DNT, and nitrosamines [NAMs]), anions, and priority pollutant metals. Selected samples were also tested for leaching potential, using TCLP analysis for the metals CD, CR, HG, and PB.

Two soil borings were drilled at Landfill 1 to establish the nature and depth of waste materials and to characterize the vertical distribution of any contaminants leached from this site (see Figure 3-13). LOB-90-01, located near the center of Landfill 1,

encountered 15 feet of waste material, including vitreous slag, ash, asphalt, and wood. This boring was advanced 141.5 feet bgs to the water table. LOB-90-02, located at the periphery of Landfill 1, encountered only 1 foot of waste over native soil. This boring was terminated at 20 feet because of a lack of visible contamination.

The distribution of chemicals in the subsurface soil indicates that Waste Pits WP-1, WP-2, and WP-3 in the Contaminated Waste Area are potential sources of VOCs, SVOCs, NAMs, and DNTs. Soil boring PBB-91-06 in WP-1 contains the highest concentrations of 24DNT, TRCLE, and C6H6 in a zone from 12 to 91 feet bgs. The distribution of C6H6, TRCLE, and DNTs with respect to depth at the Waste Pits is shown in Figures 3-14, 3-15, and 3-16, respectively. Although boring data was not sufficient to obtain complete vertical distribution of other propellant-related contaminants (e.g., NNDPA), potentially high concentrations of these contaminants in subsurface soil are suspected.

Available data indicate that subsurface soil in the Contaminated Waste Area is contaminated with DNTs and various SVOCs attributable to past disposal practices at BAAP. Historical records indicate that WP-1, 2, and 3 were used to dispose of spent solvents and production wastes, possibly including deterrent. The two existing Waste Pits WP-2 and WP-3 (PBB-91-04 and PBB-91-05) are approximately 12 to 16 feet deep. Based on the depth of fill encountered during drilling, WP-1 (PBB-91-06) has been filled with approximately 12 feet of soil. Borings PBB-91-04 and PBB-91-05 were placed at the edge of the unfilled waste pits as the centers of the pits were inaccessible (see Figure 3-13). Samples from these borings may not have been collected from the most contaminated areas. Consequently, the results from these two borings likely underestimate maximum concentrations of VOCs and SVOCs in these pits. Concentrations of these contaminants are likely to be higher in the centers of the pits, corresponding to more probable areas of activity. Therefore, all three pits represent potential sources of contamination of DNTs and VOCs in the groundwater.

In general, most VOCs, SVOCs, and NAMs were detected at 12 feet or deeper. This is consistent with the depth of fill noted in PBB-91-06. The SVOCs most commonly reported, and at the highest concentrations, were 24DNT, 26DNT, and NNDPA. PBB-91-06 contains the highest concentration of 24DNT and 26DNT, and in the same samples in which high concentrations of VOCs were noted; this confirms that the interval from 12 to 91 feet bgs is a major zone of contamination. The highest DNT concentration was at 16 feet, where the soil sample contained 28 percent 24DNT (280,000 micrograms per gram [$\mu$g/g]). PBB-91-04 has a contaminated zone

between approximately 30 and 72 feet bgs. However, there are two contaminated zones associated with PBB-91-05 at WP-2, one from 24 to 32 feet bgs and one from 69 to 73 feet bgs. Some of these apparent differences likely reflect the degree of lateral spreading of the contaminated solvents in the subsurface outside of WP-2 and WP-3.

The presence of DNTs at depths of 91 feet bgs confirms the potential for these Waste Pits to be sources of groundwater contamination. VOCs are detected down to the same depth as the DNTs. Volatilization of VOCs, resulting in possible lateral or upward migration, may compete with infiltration and may account for the vertical distribution of the VOCs. The Waste Pits are a likely groundwater contamination source by virtue of the high concentrations detected. It appears the principal mechanism driving groundwater contamination is the passage of wetting fronts from infiltrating precipitation through the concentrated contamination in the unsaturated zone.

Zones of VOC and SVOC contamination similar to those identified in PBB-91-04, -05, and -06 were not detected in borings PBB-91-01, -02, -03, and -07. The Refuse Pits and Old Burn Area do not appear to represent major sources of potential contamination. Chemical data from PBB-91-07 (located in the Old Burn Area) also indicates that the maximum lateral spreading of VOCs and SVOCs in subsurface soils from the center of the Waste Pits is less than 125 feet, the distance from PBB-91-07 to WP-1.

Ten subsurface soil samples were collected for chemical analysis from LOB-90-01 and LOB-90-02 drilled in Landfill 1. No VOCs or SVOCs were detected in the borings. However, concentrations of metals (PB, CU, and ZN) above background levels were detected in the fill and ash of the upper 10 feet of the borings. These elevated concentrations of metals decreased to background concentrations with increasing depth below the fill material. The exception to this trend was seen in the 20- and 25-foot samples from LOB-90-01, where elevated concentrations of CU were detected. This apparent lack of migration is consistent with the expected environmental behavior of these metals under conditions likely to be encountered in soil and groundwater systems.

Concentrations of PB and other metals above background levels are primarily limited to surface soils at the Propellant Burning Ground, with little evidence of vertical migration. PB, CU, and ZN detected in test pits and soil borings from Landfill 1 and the 1949 Pit area reflect this condition. Although concentrations of these metals are

high in the upper 10 feet of the test pits and borings, they generally decrease with depth. This apparent lack of migration downward through the soil column is consistent with the expected environmental behavior of these metals under conditions likely to be encountered in natural soil and groundwater systems. In general, PB, CU, and HG are strongly bound by soil particles (particularly organic matter) and usually exhibit limited mobility except under very low or high pH conditions (i.e., pH less than 4 or greater than 9, or when they have formed mobile complexes). Based on available data, Landfill 1 and the 1949 Pit do not appear to represent major potential sources for metals contamination to groundwater. AS and ZN are generally considered moderately mobile compared to other metals, but may form stable bridged complexes with particle surfaces, and may be precipitated or coprecipitated with hydrous metal oxides of other species.

### 3.3.3 Contamination Assessment - Groundwater

Two separate groundwater sampling episodes were undertaken by ABB-ES at BAAP. During the first sampling episode, in September and October of 1990, two limited rounds of groundwater samples (1990 Round I and 1990 Round II) were collected from selected wells (PBN-89-04B,C and SPN-89-03B,C) in the Propellant Burning Ground and along the southern base boundary, west of the Settling Ponds. Samples were collected from the four monitoring wells and analyzed for the following VOCs: 1,1-dichloroethylene (11DCE), 1,1-dichloroethane (11DCLE) (Round II only), 1,2-dichloroethylene (12DCE), 12DCLE (Round II only), CCL4, chloroform (CHCL3), and TRCLE. Only select VOCs were analyzed in an attempt to more clearly define the off-post VOC plume. During the second sampling episode, two complete rounds of groundwater samples (182 samples total) were collected in November and December of 1991 (Round One) and April and May of 1992 (Round Two) from 93 monitoring wells located in the Propellant Burning Ground. Locations of sampled wells are shown in Figure 3-6. Groundwater samples were analyzed for VOCs, SVOCs (including NG, 24DNT, 26DNT, and NAMs), anions, CD, CR, HG, PB, and other toxic analyte list metals during the second sampling episode.

Groundwater beneath the Propellant Burning Ground has been shown to be contaminated with VOCs (i.e., CCL4, TRCLE, CHCL3, and 1,1,1-trichloroethane [111TCE]). A summary of VOC groundwater data is shown in Figure 3-17. The VOC contamination appears to be migrating southward from the Propellant Burning Ground Area and deeper into the sand and gravel aquifer. Cross sections of the plumes of CCL4 and TRCLE, the primary groundwater contaminants, are oriented as depicted in Figure 3-18 and shown in Figures 3-19 and 3-20, respectively. Data

from off-post wells south of BAAP confirm that VOCs have migrated off installation. The following paragraphs provide interpretations of the behavior of the VOC groundwater contaminants in the Propellant Burning Ground.

A plan view of the CCL4 plume is shown in Figure 3-21. CCL4 concentrations of approximately 100 micrograms per liter ($\mu$g/L) were detected in two zones: one just south of the Racetrack Area, and the other at the southern base boundary. Between these two zones, concentrations of CCL4 decrease to less than 40 $\mu$g/L. Several possible explanations for these conditions are: (1) the heterogeneity of the soils and screened intervals of monitoring wells are responsible for the observed CCL4 distribution, and/or (2) the two areas of elevated CCL4 concentrations are evidence of "pulses" of CCL4 from a source in the soils in the vicinity of the Propellant Burning Ground (e.g., natural leaching by infiltration is a cyclical process).

The most likely source area for TRCLE detected in groundwater is the Contaminated Waste Area in the Propellant Burning Ground. TRCLE was detected in subsurface soils beneath and adjacent to Waste Pits 1, 2, and 3 at concentrations in excess of 39 $\mu$g/g. The Waste Pits appeared between 1968 and 1974, which correlates well with the reported historical use of TRCLE at BAAP. The USAEHA (1985) reported that TRCLE was burned with lumber in the three Waste Pits. Passive soil vapor survey results confirm the presence of TRCLE in subsurface soils beneath the Waste Pits of the Contaminated Waste Area. The relatively low concentrations and less consistent detection of TRCLE in groundwater at the southern base boundary support the fact that TRCLE was used (and disposed of) at BAAP more recently than CCL4.

A plan view of the TRCLE plume is shown in Figure 3-22. The highest concentrations of TRCLE detected in groundwater are immediately south of the Contaminated Waste Area in well PBN-82-02. The TRCLE plume is similar in horizontal extent to the CCL4 plume, except for being half the width of the CCL4 plume at the base boundary. TRCLE was detected upgradient (well PBM-89-09) and crossgradient (wells PBM-82-01 and LON-89-03) from the suspected sources in the Contaminated Waste Area. This may be the result of a combination of subsurface lateral as well as vertical dispersion and/or vapor-phase transport through the unsaturated zone from the subsurface soils beneath the Contaminated Waste Area.

CHCL3 was detected in two rounds of sampling in 55 of 88 wells in the Propellant Burning Ground. Concentrations of CHCL3 detected in groundwater were generally less than 10 $\mu$g/L. The distribution of CHCL3 is nearly identical to that of CCL4.

Although no CHCL3 was detected in soils by ABB-ES, the MEP reports CHCL3 in subsurface soils at the Contaminated Waste Area ranging from 1 to 2 $\mu$g/g. Because of its high vapor pressure and poor soil affinity, CHCL3 detected in subsurface soils in the mid-1980s (and reported in the MEP) could have evaporated and/or partitioned into infiltrating precipitation. CHCL3 may have been an impurity in solvents (e.g., CCL4) used at BAAP.

Relatively low concentrations of CCL4, TRCLE, and CHCL3 were observed at the water table at Landfill 1. However, the concentrations were similar upgradient and immediately downgradient of Landfill 1. No source of VOCs was found in subsurface soils from borings LOB-90-01 and 02. One possible explanation for the detection of VOCs in groundwater beneath Landfill 1 is a combination of subsurface lateral as well as vertical dispersion and/or vapor-phase transport through the unsaturated zone from suspected source areas to the west in the Propellant Burning Ground. Decreasing concentrations of VOCs to the north of Landfill 1 in wells LOM-89-01, LOM-91-01, and 02 apparently indicate there is no source area upgradient of Landfill 1.

111TCE is commonly used as a degreasing agent, and was probably used at BAAP. Groundwater data from the Propellant Burning Ground indicate that the source for 111TCE is in the vicinity of the Propellant Burning Ground. 111TCE was detected infrequently in subsurface soil samples from the Contaminated Waste Area, and at concentrations less than 0.005 $\mu$g/g. These concentrations and frequency of detection do not indicate a significant current source of 111TCE in subsurface soils. One hypothesis is that the 111TCE has evaporated and/or been leached from the subsurface soils. Another possibility is that an unidentified source of 111TCE exists in the vicinity of the Propellant Burning Ground.

Based upon observed concentrations of C6H6 in subsurface soils of the Contaminated Waste Area, one would expect to find C6H6 in groundwater beneath the Propellant Burning Ground. However, C6H6 was detected only once, in well PBN-82-04C at a concentration of 1.76 $\mu$g/L.

The principal SVOC contaminants detected in groundwater were 26DNT and NNDPA. Wells PBN-82-05B and PBN-89-04B were the only locations in which 26DNT was consistently detected (Figure 3-23). 26DNT was detected in only one of the two rounds in wells PBN-82-05A and PBM-85-03. Seasonal variations in precipitation, or sampling and laboratory variations could explain this variability in the data. Groundwater data show that 26DNT has migrated only a fraction of the

distance that TRCLE and CCL4 have migrated. Further, concentrations of 24DNT in subsurface soils beneath the Contaminated Waste Area far exceed those of 26DNT; yet 24DNT was not detected in groundwater.

In contrast to the pattern shown by VOCs, the highest 26DNT concentrations were found deeper in the aquifer in well nest PBN-82-05. This nest is downgradient from the Waste Pits in the Contaminated Waste Area (and the Racetrack) where DNTs were detected in the subsurface soils. These Waste Pits represent possible sources of 26DNT in groundwater.

NNDPA distribution in groundwater is very similar to that of 26DNT (see Figure 3-23). The maximum concentration of NNDPA detected was 25 $\mu g/L$, in well PBM-85-03 south of the Racetrack. NNDPA was detected in subsurface soils of the Contaminated Waste Area, which represents a possible source for this chemical detected in groundwater.

Several inorganics were detected above background concentrations and/or Wisconsin standards in the Propellant Burning Ground wells. CD, CR, HG, and PB were the major metals detected above Wisconsin standards in some wells. Nitrate/nitrite (NIT), chloride (CL), and SO4 were the anions analyzed. NIT and SO4 were detected at concentrations above background in groundwater at this site.

Although CD, CR, and PB were detected in soils at the Propellant Burning Ground, these metals appear to be bound in the upper soil layers with minimal migration down to the groundwater. CD, CR, HG, and PB were detected at low concentrations in Round One. None of these metals were detected in Round Two. Other metals were detected within background ranges with the exception of calcium (CA), which appeared slightly elevated in the area of Landfill 1.

NIT in the groundwater at the Propellant Burning Ground appears related to agricultural practices at BAAP rather than past production and waste disposal. Analyses of the wells located around Landfill 1 reported NIT concentrations above typical background levels. Elevated NIT concentrations were detected below the water table in the B series wells, which would indicate a source of NIT upgradient of Landfill 1. Samples from wells in the immediate vicinity and just downgradient of the Contaminated Waste Area and Burning Pads have relatively lower NIT concentrations. These data, together with the results from upgradient well PBM-89-11, suggest that the Propellant Burning Ground is not the NIT source. The southern area of high NIT concentrations does not correlate with the VOC plumes,

whose origins are believed to be related to the Propellant Burning Ground. VOC concentrations increase with depth, while NIT concentrations decrease with depth. If the source areas were similar, the high NIT concentration should have a distribution pattern similar to that of the VOCs in groundwater.

One isolated area of SO4 concentrations above the 41,000 $\mu$g/L background concentration is evident in wells PBN-82-05B and PBN-89-01B south of the Propellant Burning Ground. Wells PBN-82-05B and PBN-89-01B are downgradient from potential source areas in the Propellant Burning Ground. It is possible that elevated concentrations of SO4 detected in groundwater from these wells are attributable to elevated concentrations of SO4 in subsurface soils from the Propellant Burning Ground.

### 3.4 Development of Remedial Action Objectives

The baseline risk assessment for the Propellant Burning Ground presented in the Final RI Report included a human health evaluation and an environmental assessment (ABB-ES, 1993a). The baseline risk assessment determined that there is an unacceptable risk to human receptors from PB in surface and subsurface soils and from multiple contaminants in groundwater. Subsequent to the finalization of the RI Report, numeric soil clean-up standards for AS, CD, CR, and PB based on human health risk and numeric soil clean-up standards for C6H6, 12DCLE, ETC6H5, MEC6H5, and TXYLEN based on protection of groundwater have been presented in the proposed Wisconsin Chapter NR 720. For human health risk, two separate sets of clean-up standards are provided; non-industrial and industrial land use (see Subsection 1.4.1). Procedures for calculating clean-up standards for chemicals without listed numeric standards and procedures for calculating alternative clean-up standards are also included in the proposed Chapter NR 720. Applying the lowest of the human health (assuming industrial land use) and protection of groundwater standards from the proposed Chapter NR 720 for each COC results in soil clean-up levels that are more stringent than those calculated using the criteria used in the baseline risk assessment for human health. Consequently, Propellant Burning Ground soil clean-up levels for protection of human health and protection of groundwater were developed using criteria in the proposed Chapter NR 720 (see Subsection 1.4.1 and 1.5). Soil clean-up levels for protection of ecological receptors were developed using the original risk assessment criteria contained in the Final RI Report.

This subsection presents the COCs identified in the Final RI Report and summarizes the risks to human and ecological receptors. The remedial action objectives developed in this subsection, which incorporate clean-up standards, are designed to reduce the risks posed by site contaminants to acceptable levels.

### 3.4.1 Summary of Human Health Evaluation

Surface soil (i.e., zero to 2 feet bgs), subsurface soil (i.e., zero to 15 feet bgs), and groundwater are the contaminated media that humans might be exposed to at the Propellant Burning Ground. The soil exposure scenario (provided in the proposed Chapter NR 720) evaluated at the Propellant Burning Ground was incidental ingestion of soil (surface and subsurface) and inhalation of particulate matter for an adult worker. Because BAAP is currently in standby status and will be government-owned for the foreseeable future, resident exposures will not occur. Consequently, the non-industrial exposure scenario provided in the proposed Chapter NR 720 was not evaluated. In addition to evaluating the human health risks from exposure to contaminated soil, the potential for contaminants leaching from soil (surface and subsurface) and degrading groundwater quality in excess of WPALs was evaluated per the proposed Chapter NR 720.

Although scenarios associated with exposure to Propellant Burning Ground groundwater were not evaluated, groundwater quality was compared to state and/or federal groundwater standards or risk-based concentrations.

**3.4.1.1 Selection of Human Health Contaminants of Concern.** Human health chemicals of concern (HCOCs) are chemicals with inherent toxic/carcinogenic effects that are likely to pose the greatest threat to human receptors. HCOCs are present in surface soil, subsurface soil, and groundwater at the Propellant Burning Ground. Based on the frequency of occurrence, the range of concentrations compared to background levels, and other screening criteria, the HCOCs in soil were selected and are presented in Table 3-1.

**3.4.1.2 Human Health Risk Characterization.** Soil clean-up standards protective of human health, calculated using procedures outlined in the proposed Chapter NR 720, that will reduce the carcinogenic and/or noncarcinogenic risk from surface and subsurface soil contaminants to acceptable levels are presented in Table 3-2. Potential human receptors at the site are expected to be at risk from 24DNT, carcinogenic polynuclear aromatic hydrocarbons (CPAH), AS, and PB in surface soil and 24DNT, 26DNT, CPAH, C6H6, AS, and PB in subsurface soil. Because there

are no dose-response values for PB, the clean-up standard for this chemical was not calculated but was obtained using the numeric standard (i.e., 500 ppm for industrial land use) listed in the proposed Chapter NR 720.

Soil clean-up standards protective of groundwater are also presented in Table 3-2. Soil contaminants which are currently a potential threat to groundwater quality are 24DNT, 26DNT, TRCLE, AS, CR, PB, SE, and ZN. Leaching models were developed following the procedures outlined in the proposed Chapter NR 720, and all HCOCs were modeled to determine if the concentrations of the HCOCs in surface and subsurface soil would potentially result in exceedances of WPALs in groundwater. For organic contaminants, leaching model parameters included the partitioning between soil and water, volatilization, and degradation during migration. For metals, the only leaching model parameter was the partitioning between soil and water during migration. No modeling was attempted for anionic HCOCs (i.e., NIT and SO4) because no models exist to predict concentrations during migration of these contaminants.

Contaminant concentrations in groundwater exceed groundwater standards. Table 3-3 summarizes the chemicals detected in the groundwater, the frequency of detection, and the minimum and maximum detected concentrations. Concentrations of CCL4, NIT, 26DNT, CHCL3, TRCLE, and HG exceed WESs. Concentrations of CR, PB, 111TCE, and CD are below WESs but exceed WPALs. Additionally, concentrations of manganese (MN) and SO4 exceed public welfare standards, while sodium (NA) exceeds a reporting level for sodium-restricted diets. Although there are no promulgated Wisconsin criteria for BE and NNDPA, WDNR has established interim WESs and WPALs for BE and NNDPA. The maximum concentration of NNDPA exceeds its interim WES and the maximum concentration of BE exceeds its interim WPAL.

### 3.4.2 Summary of Baseline Environmental Assessment

No permanent water bodies are associated with the Propellant Burning Ground. As a result, only terrestrial organisms will likely be exposed to contamination in the area. Surface soil (i.e., zero to 2 feet bgs) is the only medium to which terrestrial organisms may be exposed. Incidental soil ingestion and consumption of contaminated food are the likely exposure pathways for potential ecological receptors.

**3.4.2.1 Selection of Ecological Contaminants of Concern.** Ecological contaminants of concern (COCs) are those chemicals having inherent toxic/carcinogenic effects that are likely to pose the greatest threat to ecological receptors. ECOCs are present only in surface soil at the Propellant Burning Ground. Based on the frequency of occurrence, the range of concentrations found compared to background levels, and other screening criteria, ECOCs were selected and are presented in Table 3-4.

The frequency of detection and the exposure point concentrations for the ECOCs are also presented in Table 3-4. Except for SE, the inorganic COCs were detected more frequently than organic COCs in surface soil samples. However, 24DNT was detected in more than 10 percent of the samples collected.

**3.4.2.2 Ecological Risk Characterization.** Ecological receptors occurring at the site are expected to be at risk for acute and chronic exposures. The HIs associated with both acute and chronic exposures exceeded 1 and ranged over several orders of magnitude (Table 3-5). These results suggest that small mammals, such as the short-tailed shrew, are at greatest risk from exposure to surface soil constituents at the Propellant Burning Ground (HIs for acute and chronic exposures are 5,500 and 111,000, respectively). Under both acute and chronic exposure assumptions, PB accounted for most of the estimated risk to this group of terrestrial receptors. In addition, CU was determined to be a risk contributor to small mammals for chronic exposures. The acute and chronic HIs estimated for this group of receptors are sufficiently high to suggest that impacts are likely.

HIs for the other modeled indicator species are lower than those estimated for small mammals. However, individual meadowlarks (and other birds with similar diets) and garter snakes (and other reptiles) that forage regularly in the vicinity of the Propellant Burning Ground would also likely be impacted (chronic HIs are 2,000 and 6,300 for the bird and snake, respectively). Approximately 90 percent of the overall chronic and acute risk to these receptors is associated with dietary exposure to CU and PB, with HG, SE, and ZN accounting for most of the remaining risk.

### 3.4.3 Identification of Remedial Action Objectives - Surface Soil

The human health risk characterization indicates that concentrations of 24DNT, CPAH, AS, and PB in surface soil exceed clean-up standards for protection of human health developed and/or obtained from the proposed Chapter NR 720. In addition to excessive risks to human health, soil leaching models indicate that AS, CR, PB, SE, and ZN in surface soil exceed clean-up standards for protection of groundwater,

also developed from the proposed Chapter NR 720. The baseline environmental assessment indicates that the ecological risks from exposure to CU, HG, PB, SE, and ZN by incidental surface soil ingestion and consumption of contaminated prey by terrestrial organisms exceed those considered acceptable using USEPA risk guidance. Not identified as a source of excessive risk in the human health risk characterization or the baseline ecological assessment, but suspected of containing high concentrations of DNTs, surface soil in WP-2 and WP-3 is potentially a risk to human and ecological receptors. This subsection identifies the remedial action objectives that would reduce the human health and ecological risks associated with contaminated soil to acceptable levels, and reduce the potential for further degradation of groundwater quality from surface soil contaminants leaching into groundwater.

Based on the site conditions, nature of the contaminants, migration pathways, and conclusions of the human health risk characterization and baseline environmental assessment, the following specific remedial action objectives for contaminated surface soil have been formulated:

1) Prevent concentrations of 24DNT, CPAH, AS, and PB in surface soil which exceed clean-up standards for protection of human health (developed and/or obtained from the proposed Chapter NR 720) from becoming available, either through incidental ingestion of soil or inhalation of particulates, to potential human receptors.

2) Prevent concentrations of CU, HG, PB, SE, and ZN in surface soil that pose an unacceptable risk from becoming available, either through incidental ingestion or consumption of contaminated prey, to potential ecological receptors.

3) Prevent concentrations of AS, CR, PB, SE, and ZN in surface soil which exceed clean-up standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs.

4) Prevent concentrations of DNTs in surface soil in WP-2 and WP-3 which exceed clean-up standards for protection of human health and groundwater (developed from the proposed Chapter NR 720) and/or pose an unacceptable risk to potential ecological receptors from becoming available to potential receptors or degrading groundwater quality.

Table 3-6 lists the contaminants in surface soil to be addressed during remediation, detection limits, maximum detected concentrations at the Propellant Burning Ground, maximum background concentrations (for metals in surface soil), clean-up standards for the protection of human health and groundwater (developed and/or obtained from the proposed Chapter NR 720), acceptable ecological risk-based concentrations, and the recommended remediation goal with associated rationale. The maximum background concentrations are the high end of the range of either the BAAP or the regional background concentrations presented in the RI report, whichever is greater.

Table 3-6 indicates that maximum background concentrations have been selected as the remediation goals for AS, CU, HG, PB, SE, and ZN. Although background concentrations of these metals exceed clean-up standards for protection of human health and protection of groundwater, and/or exceed ecological risk-based values, there would be no significant benefit to potential receptors within BAAP or to the regional aquifer by remediating surface soil within small isolated areas to below background concentrations. Additionally, for most of the contaminants, the clean-up standards and/or the ecological risk-based values are below detection limits. Remediation goals set below detection limits would obviously be unmeasurable and would probably be unattainable by most (if not all) existing soil remediation technologies.

### 3.4.4 Identification of Remedial Action Objectives - Subsurface Soil

The human health risk characterization indicates that concentrations of 24DNT, 26DNT, CPAH, C6H6, AS, and PB in subsurface soil exceed clean-up standards for protection of human health developed and/or obtained from the proposed Chapter NR 720. In addition to excessive risks to human health, soil leaching models indicate that 24DNT, 26DNT, TRCLE, AS, CR, PB, SE, and ZN in subsurface soil exceed clean-up standards for protection of groundwater, also developed from the proposed Chapter NR 720. There are no ecological risks associated with subsurface soil. This subsection identifies the remedial action objectives that would reduce the human health risks associated with contaminated soil to acceptable levels, and reduce the potential for further degradation of groundwater quality from subsurface soil contaminants leaching into groundwater.

Based on site conditions, nature of the contaminants, migration pathways, and conclusions of the human health risk characterization, the following specific remedial action objectives for contaminated subsurface soil have been formulated:

1) Prevent concentrations of 24DNT, 26DNT, CPAH, C6H6, AS, and PB in subsurface soil which exceed clean-up standards for protection of human health (developed and/or obtained from the proposed Chapter NR 720) from becoming available, either through incidental ingestion of soil or inhalation of particulates, to potential human receptors.

2) Prevent concentrations of 24DNT, 26DNT, TRCLE, AS, CR, PB, SE, and ZN in subsurface soil which exceed clean-up standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs.

Table 3-7 lists the contaminants in subsurface soil to be addressed during remediation, detection limits, maximum detected concentrations at the Propellant Burning Ground, maximum background concentrations (for metals in subsurface soil), clean-up standards for the protection of human health and groundwater (developed and/or obtained from the proposed Chapter NR 720), and the recommended remediation goal with associated rationale. The maximum background concentrations are the high end of the range of either the BAAP or the regional background concentrations presented in the RI report, whichever is greatest.

Table 3-7 indicates that detection limits have been selected as the remediation goals for 24DNT, 26DNT, AS, and SE. Because the detection limits are greater than the clean-up standards developed for these contaminants, the remediation goals could result in inadequate protection for human receptors and/or groundwater quality. However, remediation goals set below detection limits would obviously be unmeasurable and would probably be unattainable by most (if not all) existing soil remediation technologies.

Table 3-7 also indicates that maximum background concentrations have been selected as the remediation goals for CR and PB. Although background concentrations of CR and PB exceed clean-up standards for protection of groundwater, there would be no significant benefit to the regional aquifer by remediating subsurface soil within small isolated areas to below background concentrations.

### 3.4.5 Identification of Remedial Action Objectives - Groundwater

There are no ecological risks associated with groundwater. The human health risk characterization indicates the following:

- concentrations of CCL4, NIT, 26DNT, CHCL3, TRCLE, and HG exceed WESs;
- concentrations of CR, PB, 111TCE, and CD are below WESs but exceed WPALs;
- concentrations of BE are below the interim WES but exceed the interim WPAL and concentrations of NNDPA exceed the interim WES;
- concentrations of MN and SO4 exceed public welfare standards; and
- concentrations of NA exceed the level considered protective of receptors on sodium-restricted diets.

Based on site conditions, nature of contaminants, migration pathways, and conclusions of the human health risk characterization, the following remedial action objectives for contaminated groundwater have been formulated:

1) Prevent further migration of contaminated groundwater.
2) Reduce the concentrations of CCL4, 26DNT, CHCL3, TRCLE, 111TCE, CR, PB, CD, and HG to their respective WPALs.
3) Reduce the concentrations of BE and NNDPA to their respective interim WPALs.
4) Reduce the concentrations of MN and SO4 to a level at or below public welfare standards.

Table 3-8 presents contaminants in groundwater requiring remediation, maximum concentrations at the Propellant Burning Ground, acceptable ARAR-based or human health-based concentrations (as applicable), and the selected remediation goal with associated rationale.

The reduction of CCL4, 26DNT, CHCL3, TRCLE, 111TCE, CR, PB, CD, and HG concentrations to their respective WPALs will result in levels protective of human health. As stated in Subsection 2.6, chemical-specific ARARs are generally health- or risk-based and represent an acceptable concentration of that chemical in

environmental media. The WPAL is the chemical-specific ARAR selected as the remediation goal for CCL4, 26DNT, CHCL3, TRCLE, 111TCE, CR, PB, CD, and HG because it is a promulgated standard and is more stringent than the MCL for each of these contaminants, except 26DNT and CHCL3, which have no assigned MCL.

Although NIT has been identified as a COC in groundwater, and the maximum concentration of NIT exceeds the WES, agricultural practices, rather than past production and waste disposal, is the likely source of the high NIT concentrations in groundwater at the Propellant Burning Ground. The Wisconsin Groundwater Quality Standards provide exemptions from regulations for similar situations. As described in NR 140.26(4), "If nitrates or any substance of welfare concern only attains or exceeds an enforcement standard, the department is not required to impose a prohibition or close a facility if it determines that: (a) the enforcement standard was attained or exceeded, in whole or in part, because of high background concentrations of the substance, and; (b) the additional concentration does not represent a public welfare concern." Given the land use (i.e., agricultural) in the vicinity of the Propellant Burning Ground and the low potential for exposure to groundwater in this area, an exemption from the WES for NIT is appropriate. As such, remedial action objectives for NIT in groundwater are not being proposed.

The reduction of BE and NNDPA concentrations to their respective interim WPALs will result in levels protective of human health. The Wisconsin Department of Health and Social Services, Division of Health, established the interim State Drinking Water Standards to use until final standards for BE and NNDPA are promulgated.

The reduction of MN and SO4 concentrations to their respective drinking water standards will result in acceptable color and odor. These are welfare-based standards concerned with the aesthetic quality of water; not based on human health considerations.

Although the maximum concentration of NA exceeds the reporting level of 20,000 $\mu$g/L, no remedial action objective is proposed. The associated regulatory requirement is monitoring and reporting of data to health officials to protect individuals on sodium-restricted diets. Monitoring and reporting NA concentrations in groundwater will occur indirectly via implementation of the remedial action objectives for groundwater.

## 3.5 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

This subsection identifies and screens remedial technologies for soil and groundwater remediation at the Propellant Burning Ground. A description of the technology identification and screening process is presented in Subsection 1.5. The result is an inventory of technologies retained for developing remedial alternatives. Remedial alternatives development and initial screening is presented in Subsection 3.6.

### 3.5.1 Remedial Technology Identification and Screening for Soil

This subsection identifies and screens remedial technologies for Propellant Burning Ground soil.

**3.5.1.1 Remedial Technology Identification - Soil.** Table 3-9 identifies general response actions and remedial technologies potentially applicable to Propellant Burning Ground soil.

**3.5.1.2 Remedial Technology Screening - Soil.** Technology screening is shown in Table 3-10. Technologies judged neither effective nor implementable were eliminated from further consideration. The technologies remaining after screening, summarized in Table 3-11, were subsequently used to develop remedial alternatives.

### 3.5.2 Remedial Technology Identification and Screening for Groundwater

This subsection identifies and screens remedial technologies for Propellant Burning Ground groundwater.

**3.5.2.1 Remedial Technology Identification - Groundwater.** Table 3-12 identifies general response actions and remedial technologies potentially applicable to Propellant Burning Ground groundwater.

**3.5.2.2 Remedial Technology Screening - Groundwater.** Technology screening is shown in Table 3-13. Technologies judged not effective or implementable were eliminated from further consideration. The technologies remaining after screening, summarized in Table 3-14, were subsequently used to develop remedial alternatives.

## 3.6 DEVELOPMENT AND INITIAL SCREENING OF REMEDIAL ALTERNATIVES

In this subsection, technically feasible remedial technologies for soil and groundwater at the Propellant Burning Ground (retained after screening in Subsection 3.5) are assembled into remedial alternatives. The remedial alternatives are then screened on the basis of effectiveness, implementability, and cost. A description of the alternatives development and screening process is presented in Subsection 1.5.

For the purposes of alternatives development and screening, soil at the Propellant Burning Ground is identified as either "surface soil," "subsurface soil," or "waste pits" (i.e., WP-1, WP-2, and WP-3). The distinction between subsurface soil and waste pits was made to account for the differences in the types of contaminants (i.e., primarily metals in the subsurface soils at Landfill 1 and the 1949 Pit versus VOCs and SVOCs in the Waste Pits). Consequently, alternatives for surface soil, subsurface soil, and waste pit remediation are developed and screened separately in this subsection.

### 3.6.1 Remedial Alternatives Development for Soil

This subsection presents remedial alternatives for Propellant Burning Ground soil.

**3.6.1.1 Development of Remedial Alternatives - Surface Soil.** Six remedial alternatives were developed for surface soil at the Propellant Burning Ground. The alternatives include a minimal action alternative, a containment alternative (i.e., Soil Cover), an excavation/disposal alternative (i.e., Off-site Landfill), one treatment alternative (i.e., Soil Washing) and two treatment/containment alternatives (i.e., Stabilization/Solidification [S/S] - Soil Cover and Modified In Situ S/S - Soil Cover). The alternatives are identified in Table 3-15, and described in further detail in Table 3-16. A general discussion of the alternatives is provided in the following paragraphs.

Minimal Action. The minimal action alternative (i.e., PBG-SS1) does not include containment or treatment of contaminants. This alternative includes measures to prevent human and ecological exposure to surface soil contaminants. Fencing would discourage physical access to the site for human and some ecological (e.g., deer) receptors. Institutional controls (i.e., zoning and deed restrictions) and educational programs would provide added protection to human receptors. Because contaminants would remain on site, long-term management in the form of groundwater monitoring and five-year site reviews is included.

Containment. One containment alternative (i.e., Soil Cover) was developed to mitigate both migration of surface soil contaminants and human and ecological exposure to contaminants. Soil Cover (i.e., PBG-SS2) would provide an increased level of protection to receptors beyond that provided by the minimal action alternative. The soil would function as a physical barrier between contaminants and human and ecological receptors. When graded properly, it would also reduce surface soil transport from the site via erosion. Components of the minimal action alternative (i.e., institutional controls and long-term management through groundwater monitoring and five-year site reviews) would be included to protect the soil cover from invasive activities and to monitor for potential migration of contaminants.

Excavation/Disposal. One excavation/disposal alternative (i.e., Off-site Landfill) was developed to remove contaminants and associated risks from the site. Off-site Landfill (i.e., PBG-SS3) would transfer the contaminated soil to a more secure location. Long-term management is not included, although groundwater monitoring would be part of the selected groundwater remediation alternative.

Treatment/Containment. Two treatment/containment alternatives (i.e., S/S - Soil Cover and Modified In Situ S/S - Soil Cover) were developed to treat surface soil and bury the treatment residuals under a soil cover. S/S - Soil Cover (i.e. PBG-SS4) includes excavation and treatment while Modified In Situ S/S - Soil Cover (i.e., PBG-SS6) would include both treatment in situ and excavation and treatment.

S/S - Soil Cover and Modified In-Situ S/S - Soil Cover provide a higher level of protection than the minimal action and containment alternatives. Contaminants would be physically and/or chemically immobilized, resulting in negligible potential for migration. Additionally, the available surface area of the contaminants would be reduced by the process, effectively reducing the concentrations to which human and ecological receptors could be exposed. Components of the minimal action alternative (i.e., institutional controls and long-term management through groundwater monitoring and five-year site reviews) would be included to protect the soil cover from invasive activities and to monitor for potential migration of contaminants.

Treatment. One treatment alternative (i.e., Soil Washing) was developed to treat surface soil and backfill clean soil. Soil Washing (i.e., PBG-SS5) includes excavation and treatment but does not include a soil cover.

Soil Washing is the only treatment alternative that would reduce the concentration of surface soil contaminants. After washing, contaminants would be concentrated in a fraction of the original volume of soil and transported to an off-site landfill. The remediation goals would be attained in the treated soil backfilled into the excavations. Because contaminants would be removed from the site, long-term management at the site is not included, although groundwater monitoring would be included as part of the selected groundwater remediation alternative selected for the Propellant Burning Ground.

**3.6.1.2 Development of Remedial Alternatives - Subsurface Soil.** Three remedial alternatives were developed for subsurface soil at the Propellant Burning Ground (i.e., Landfill 1 and the 1949 Pit). These include a minimal action alternative, a containment alternative (i.e., capping), and an excavation/disposal alternative (i.e., Off-site Landfill). The alternatives are identified in Table 3-15, and described in further detail in Table 3-17. A general discussion of the alternatives is provided in the following paragraphs.

Minimal Action. The minimal action alternative (i.e., PBG-SB1) does not include containment or treatment of contaminants. However, this alternative includes measures to prevent human exposure to metals-contaminated subsurface soil. Institutional controls (i.e., zoning and deed restrictions) and educational programs would limit invasive activities into Landfill 1 and the 1949 Pit. Because contaminants would remain on site, long-term management in the form of groundwater monitoring and five-year site reviews is included.

Containment. One containment alternative (i.e., capping) was developed to reduce the potential mobility of metals in Landfill 1 and the 1949 Pit and prevent associated groundwater contamination. Capping (i.e., PBG-SB2) would provide an increased level of protection to groundwater beyond that of the minimal action alternative. Multilayered caps would reduce infiltration of precipitation into subsurface soil and the subsequent formation of leachate. Components of the minimal action alternative (i.e., institutional controls and long-term management in the form of groundwater monitoring and five-year site reviews) would be included to protect the caps from invasive activities and to monitor for potential migration of metals.

Excavation/Disposal. One excavation/disposal alternative (i.e., Off-site Landfill) was developed to remove metals-contaminated subsurface soil and associated risks from the site. Off-site Landfill (i.e., PBG-SB3) would transfer the contaminated soil to a more secure location. Long-term management is not included, although groundwater

monitoring would be part of the groundwater remediation alternative selected for the Propellant Burning Ground.

**3.6.1.3 Development of Remedial Alternatives - Waste Pits**. Twelve remedial alternatives were developed for the Waste Pits at the Propellant Burning Ground. These include a minimal action alternative, a containment alternative (i.e., Capping), a combination excavation/disposal/containment alternative (i.e., Off-site Landfill - Capping), four combination treatment/containment alternatives (i.e., On-site Incineration - Capping, Composting - Capping, Off-site Incineration - Capping, and In Situ Vacuum Extraction - Composting - Capping), and five treatment alternatives (i.e., In Situ Treatment, In Situ Vacuum Extraction - Bioventing, On-Site Incineration, In Situ Vacuum Extraction-Soil Washing - Composting, and In Situ S/S - Soil Cover). The alternatives are identified in Table 3-15, and described in further detail in Table 3-18. A general discussion of the alternatives is provided in the following paragraphs.

Minimal Action. The minimal action alternative (i.e., PBG-WP1) does not include containment or treatment of contaminants. However, this alternative includes measures to prevent human exposure to Waste Pit contaminants that leach from subsurface soil to groundwater, and also prevent human and ecological exposure to contaminants that are present in soil. Institutional controls (i.e., zoning and deed restrictions) and educational programs would reduce the potential for human exposure to contaminated groundwater and soil. Because contaminants would remain on site, long-term management in the form of groundwater monitoring and five-year site reviews is included.

Containment. One containment alternative (i.e., Capping) was developed to reduce the potential mobility of waste pit contaminants and associated groundwater contamination. Capping (i.e., PBG-WP2) would provide an increased level of protection to human receptors beyond that of the minimal action alternative. Multilayered caps would reduce infiltration of precipitation into subsurface soil and the subsequent formation of leachate. Components of the minimal action alternative (i.e., institutional controls and long-term management in the form of groundwater monitoring and five-year site reviews) would be included to protect the caps from invasive activities and to monitor for potential migration of contaminants.

Excavation/Disposal/Containment. One excavation/disposal/containment alternative (i.e., Off-site Landfill - Capping) was developed to reduce the volume of contaminants in Waste Pit soil and to reduce the potential mobility of contaminants

in the unexcavated soil by capping each of the Waste Pits. Off-site Landfill - Capping (i.e., PBG-WP3) would remove severely contaminated soil from each of the Waste Pits, which would reduce the volume of contaminants available to potential human receptors in addition to reducing leachate formation and resultant groundwater contamination. The Final RI report identified grossly contaminated soil to a depth of approximately 30 feet bgs in WP-1 (ABB-ES, 1993a). Similar concentrations are expected to a depth of approximately 15 feet below the bottom of the pits in WP-2 and WP-3. A cap over each pit would provide added protection to groundwater from unexcavated contaminated soil. Components of the minimal action alternative (i.e., institutional controls and long-term management in the form of groundwater monitoring and five-year site reviews) would be included to protect the caps from invasive activities and to monitor for potential migration of contaminants.

Treatment/Containment. Four treatment/containment alternatives (i.e., On-site Incineration - Capping, Composting - Capping, Off-site Incineration - Capping, and In Situ Vacuum Extraction - Composting - Capping) were developed to treat contaminated soil and to reduce the potential mobility of contaminants in the unexcavated soil by capping each of the Waste Pits. On-site Incineration - Capping (i.e., PBG-WP4), Composting - Capping (i.e., PBG-WP5), and Off-site Incineration - Capping (i.e., PBG-WP6) include excavation and treatment of soil. In Situ Vacuum Extraction - Composting - Capping (i.e., PBG-WP7) includes treatment of VOCs in situ, followed by excavation and ex situ treatment of SVOCs.

On-site Incineration - Capping, Composting - Capping, and Off-site Incineration - Capping would treat VOCs and SVOCs in the most severely contaminated upper portion of the soil column underlying the Waste Pits; In Situ Vacuum Extraction - Composting - Capping would treat VOCs throughout the unsaturated soil column beneath the Waste Pits and the SVOCs in the most severely contaminated upper portion of the soil column. In Situ Vacuum Extraction - Composting - Capping would result in a higher level of protection because it would extract the more mobile VOCs that are the predominant groundwater contaminants. Components of the minimal action alternative (i.e., institutional controls and long-term management in the form of groundwater monitoring and five-year reviews) would be included to protect the caps from invasive activities and to monitor for potential migration of contaminants.

Treatment. In Situ Treatment (i.e., PBG-WP8) consists of either flushing contaminants from the unsaturated soil column underlying the Waste Pits or mixing

in chemical oxidants and nutrients to enhance natural biological degradation of contaminants. Treatability studies would determine the most efficient of the two in situ treatment methods. In Situ Vacuum Extraction - Bioventing (i.e., PBG-WP9) consists of bioventing contaminated soil underlying the Waste Pits. A slurry/grout barrier wall would be constructed around the Waste Pits to contain vertical and lateral movement of leachate generated during in situ treatment, but would not be intended for permanent containment of wastes. Treatment would continue during implementation of In Situ Treatment and In Situ Vacuum Extraction - Bioventing until the soil remediation goals have been attained. On-site Incineration (i.e., PBG-WP10) and In Situ Vacuum Extraction - Soil Washing - Composting (i.e., PBG-WP11) would include excavation of Waste Pit soil vertically and laterally until the soil remediation goals have been attained. During implementation of PBG-WP11, In Situ Vacuum Extraction would be used for pretreatment of VOCs in soils prior to excavation and treatment of SVOCs by Soil Washing and Composting. Contaminated soil would be treated to remediation goals and backfilled in the excavations. Because of the depth of contamination (i.e., approximately 100 feet bgs in WP-1), sophisticated excavation techniques, using caissons or diaphragm walls may be required. In Situ S/S - Soil Cover (i.e., PBG-WP12) would include mixing S/S reagents in soil using specialized auger assemblies. All of the treatment alternatives would remove/permanently treat all the Waste Pit contaminants and long-term management at the site is not included, although groundwater monitoring would be part of the groundwater remediation alternative selected for the Propellant Burning Ground.

### 3.6.2 Initial Screening of Remedial Alternatives for Soil

This subsection screens remedial alternatives for Propellant Burning Ground soil.

**3.6.2.1 Initial Screening of Remedial Alternatives - Surface Soil.** The six remedial alternatives developed for Propellant Burning Ground surface soil were screened for effectiveness, implementability, and cost. Components considered for each of the evaluation criteria are presented in Figure 1-5. Alternatives screening is presented in Table 3-19. Table 3-20 presents the status of each alternative based on initial screening.

**3.6.2.2 Initial Screening of Remedial Alternatives - Subsurface Soil.** The three remedial alternatives developed for Propellant Burning Ground subsurface soil were screened for effectiveness, implementability, and cost. Components considered for each of the evaluation criteria are presented in Figure 1-5. Alternatives screening

is presented in Table 3-21. Table 3-22 presents the status of each alternative based on initial screening.

**3.6.2.3 Initial Screening of Remedial Alternatives - Waste Pits.** The twelve remedial alternatives developed for the Propellant Burning Ground Waste Pits were screened for effectiveness, implementability, and cost. Components considered for each of the evaluation criteria are presented in Figure 1-5. Alternatives screening is presented in Table 3-23. Table 3-24 presents the status of each alternative based on initial screening.

### 3.6.3 Remedial Alternatives Development for Groundwater

Seven remedial alternatives were developed for groundwater at the Propellant Burning Ground. These include a minimal action alternative and six treatment alternatives (i.e., Interim Remedial Measure [IRM] and Carbon Adsorption, IRM and Ultraviolet (UV)/Oxidation-Air Stripping, IRM and Air Stripping-Carbon Adsorption, IRM and Resin Adsorption, In Situ Biological, and IRM and UV/Reduction - Carbon Adsorption). The alternatives are identified in Table 3-25, and described in further detail in Table 3-26. The following paragraphs provide a general discussion of the alternatives.

<u>Minimal Action</u>. The minimal action alternative (i.e., PBG-GW1) does not include containment or treatment of contaminants. This alternative includes measures to prevent human exposure to groundwater contaminants. Institutional controls (i.e., zoning and deed restrictions) and education programs would reduce the potential for human exposure to contaminated groundwater. Because contaminants would remain in the aquifer for an indefinite period, long-term management in the form of groundwater monitoring and five-year site reviews is included.

<u>Treatment</u>. Six remedial alternatives (i.e., IRM and Carbon Adsorption, IRM and UV/Oxidation-Air Stripping, IRM and Air Stripping-Carbon Adsorption, IRM Resin Adsorption, IRM and In Situ Biological, and IRM and UV/Reduction - Carbon Adsorption) were developed to treat Propellant Burning Ground groundwater. Except for In Situ Biological (i.e., PBG-GW6), all the treatment alternatives include groundwater extraction and discharge of treated groundwater to Lake Wisconsin. In Situ Biological also includes groundwater extraction but at a relatively reduced rate. Extracted groundwater in In Situ Biological would be used as a medium for injection of microorganisms, nutrients, and oxygen or methane into the aquifer.

A report prepared by ABB-ES to address the requirements set forth by WDNR in the October 30, 1992 "Modification of Conditional Plan Approval of In-Field Conditions Report Dated September 14, 1987" contained an evaluation of the effectiveness of the IRM extraction and treatment system performance (ABB-ES 1993b). Modeling of the extraction well locations and screened intervals in the Propellant Burning Ground aquifer showed that, at the current pumping rates (i.e., maximum of 400 gpm), a portion of the contaminant plume is bypassing the system. Modeling also showed that an extraction rate of approximately 1,750 gpm is required for complete plume capture. Because extraction rates will be increased from the current maximum of 400 gpm to an extraction rate of 1,500 - 2,000 gpm, the treatment capacity (i.e., maximum of 400 gpm) in the existing IRM facility will be increased by a factor of four to five.

**NOTE: Subsequent to the Draft Final FS report which indicated that 1,750 gpm is required for complete plume capture, an aquifer performance test was conducted by Woodward-Clyde (W-C) (Woodward-Clyde, 1994a). The aquifer test results were used to refine parameters originally used by ABB-ES in the Propellant Burning Ground groundwater flow model. After recalibration of the groundwater flow model with revised parameters, the model was rerun by W-C to determine the flow rate from new extraction wells for complete plume capture. Modeling results indicate that an extraction rate of approximately 3,000 gpm is required for complete capture. W-C used a design flow of 3,000 gpm during design of the IRM upgrade conducted for the USACE (see Section 1). Design of the IRM upgrade has been completed and incorporates the preferred alternative presented in the Draft Final FS. Although the Final FS report does not reflect the increased flow rates used in the W-C design (i.e., 3,000 gpm), the following discussion concerning construction of a new treatment facility and remedial alternative development and initial screening still apply.**

Treatment capacity can be increased by implementing one of the following two options: (1) construct a new treatment facility adjacent to the existing IRM facility and operate both facilities, or (2) expand the existing IRM facility by the addition of treatment systems in parallel to the existing system. The first option was selected as the preferred option for the following reasons:

- It allows for continued operation of the existing IRM facility during construction;

- The IRM facility can be dedicated to potentially long-term source control because it's capacity (i.e., 400 gpm) may be sufficient for predicted flows from source control wells;
- A new facility can be constructed and dedicated to relatively short-term boundary (i.e., BAAP boundary) control; and
- Potentially more efficient technologies can be operated independently of existing technologies (i.e., carbon adsorption and air stripping) in the IRM facility.

Consequently, the IRM is coupled with ex situ treatment technologies (i.e., Carbon Adsorption, UV/Oxidation - Air Stripping, Air Stripping - Carbon Adsorption, Resin Adsorption, or UV/Reduction - Carbon Adsorption) for development and evaluation of remedial alternatives.

UV/Oxidation - Air Stripping (i.e., PBG-GW3), Air Stripping - Carbon Adsorption (i.e., PBG-GW4), and UV/Reduction - Carbon Adsorption (i.e., PBG-GW7) are alternatives with paired technologies where the first technology (i.e., UV/oxidation air stripping, and UV/reduction, respectively) in the treatment train destroys (UV/oxidation and UV/reduction) or removes (air stripping) the bulk of contaminants in the waste stream. The second technology in each alternative's treatment train (i.e., air stripping or carbon adsorption) polishes the effluent from the first technology.

A polishing step is necessary in UV/Oxidation - Air Stripping because UV/oxidation is not an efficient treatment method for CCL4 and excessive concentrations of CCL4 could remain in the effluent. Air stripping in UV/Oxidation - Air Stripping would reduce the concentration of CCL4 to an acceptable level before discharge to Lake Wisconsin.

A polishing step is necessary in Air Stripping - Carbon Adsorption and UV/Reduction - Carbon Adsorption because air stripping and UV/reduction are not effective treatment technologies for DNTs and excessive concentrations of DNTs could remain in the effluent. Carbon adsorption in Air Stripping - Carbon Adsorption and UV/Reduction - Carbon Adsorption would reduce the concentrations of DNTs to an acceptable level before discharge to Lake Wisconsin.

In Situ Biological is potentially capable of treating Propellant Burning Ground groundwater contaminants in situ. The effectiveness of In Situ Biological would depend greatly on a number of site and waste characteristics. The most critical characteristic is the presence or absence of a sustainable microbial population indigenous to the aquifer underlying the Propellant Burning Ground, having the capability of degrading chlorinated organics. Before implementation of In Situ Biological, it would have to be demonstrated that the microbes are capable of degrading all groundwater contaminants, including CCL4, which has proven to be highly resistant to biodegradation during industry testing of this technology.

### 3.6.4 Initial Screening of Remedial Alternatives for Groundwater

The seven remedial alternatives developed for Propellant Burning Ground groundwater were screened for effectiveness, implementability, and cost. Components considered for each of the evaluation criteria are presented in Figure 1-5. Alternative screening is presented in Table 3-27. Table 3-28 presents the status of each alternative based on initial screening.

## 3.7 SUMMARY OF CONTAMINATION ASSESSMENT THROUGH REMEDIAL ALTERNATIVES SCREENING

A summary of RI/FS components, from identification of contaminants of concern through remedial alternatives retained after screening, is presented in Table 3-29.

# 4.0 DETERRENT BURNING GROUND, EXISTING LANDFILL

The Deterrent Burning Ground and the Existing Landfill are disposal facilities located near one another in the northeastern corner of BAAP. Given their proximity, they share similar geologic and hydrogeologic environments and can be discussed together in this section, although the purpose of this section is to develop and screen remedial alternatives for only the Deterrent Burning Ground. Remediation is not planned for the Existing Landfill, as discussed in a separate No Action document being prepared for that site.

Portions of this document, such as site background, geology and hydrogeology, and risk assessments were excerpted from the Final RI Report (ABB-ES, 1993a). More detailed information may be found in that document.

## 4.1 SITE BACKGROUND AND HISTORY

The Deterrent Burning Ground occupies an approximate 2-acre man-made depression about 20 feet deep. The Existing Landfill, approximately 15 acres, had been in existence since BAAP was built and was closed in the spring of 1989. The approximate shapes and locations of each site are shown in Figure 4-1.

The Deterrent Burning Ground was used at BAAP for the open burning of deterrent, structural timbers, asphalt shingles, cardboard, papers, and office waste. Deterrent is a liquid extract of organic material used to modify the burning characteristics of NC. From 1966 through 1968 and 1971 through 1975, NC was reclaimed from unusable cannon propellant by benzene extraction (the presence of benzene in DBG soils may result in the identification as a listed waste - F005). This process generated a liquid waste that included deterrent (reported by Kneessy [1976] as 73.9 percent DNTs), which was poured into the pits and ignited. According to interviews with former BAAP employees, approximately 500 gallons per week of deterrent was dumped in pits located in the south burning ground (Propellant Burning Ground) from 1966 to 1970. After 1970, deterrent was dumped and burned at the north burning ground (Deterrent Burning Ground) (USATHAMA, 1977).

Further investigation into solvent-disposal activities as described by the Installation Assessment Report and the MEP indicates that a listed hazardous waste was disposed of in the burning pits at the DBG. A Point Source Pollution Engineering

Study prepared for BAAP contains a description of a process where "Single Base" additives are extracted from propellant using a solution of C6H6 and ethyl acetate (Olin Corporation, 1984). The exhausted extraction solution is pumped to a still where a large percentage of the C6H6 is recovered. Still bottoms were removed for disposal at the "burning ground". Because the percentage (by volume) of C6H6 in the extraction solution was greater than 10 percent, the C6H6 waste is a listed hazardous waste from non-specific sources (i.e., F005) per 40 CFR Part 261.31.

The Existing Landfill received essentially all the uncontaminated (i.e., non-propellant) waste generated at BAAP, including wastes from administrative offices, security guard quarters, firehouses, and limited operations in the laboratories. Waste insulation, which likely contained asbestos, reportedly was disposed of there, and coal ash wastes from the BAAP steam plant were likely disposed of there as well. Reportedly, no hazardous or propellant wastes were disposed of in the landfill.

The historical configuration of both sites can be traced using aerial photographs. Aerial photographs provided by BAAP, USEPA, and the National Archives were reviewed for the years 1944, 1949, 1955, 1962, 1968, 1974, 1978, and 1986. Figure 4-2 depicts the development of the Deterrent Burning Ground, as observed in these aerial photographs.

The Deterrent Burning Ground site existed as a borrow pit from the 1940s until the early 1960s (Whitten and Sjostrom, 1988). Aerial photographs taken between 1944 and 1962 show activity in the borrow pit apparently associated with extraction of borrow material and some activity apparently associated with burning. No activity is visible in the eastern portion of the borrow pit in these photographs. Partial filling of the western half of the borrow pit is visible in the 1968 photograph. The 1974 photographs show essentially all of the western portion of the borrow pit filled and covered with dark mounded material over the westernmost end, and three distinct areas of activity within and around the northern and eastern perimeter of the existing pit floor. The dark material may be coal bottom ash from the BAAP power plant and the three areas of activity are interpreted to be the three deterrent burning pits.

Interviews with plant personnel and review of BAAP operating history revealed that deterrent waste was burned in the eastern portion of the site and that the burning pits were closed by capping with a plastic membrane covered by 3 feet of earth (Hellewell and Mattei, 1983). It is unlikely that deterrent was burned in the western portion of the site because this area was filled when deterrent burning operations reportedly began at the Deterrent Burning Ground (1971 to 1975).

The aerial photographs trace the history of the Existing Landfill as well. Review and comparison of the photographs indicates that activity varied from uses as a sand and gravel borrow source (1944) to a general purpose landfill during the 1960s. The Environmental Assessment for the Existing Landfill states that the facility was in use since 1972 and that fill consisted of nonhazardous materials (Hellewell and Mattei, 1983).

The existing landfill cap consists of 2 feet of compacted clay overlain by 6 inches of topsoil. A grass cover has been established on the top soil layer. Final grades on the cap consist of 4:1 (25 percent) side slopes and 4 percent top slopes.

## 4.2 GEOLOGY AND GROUNDWATER CHARACTERIZATION

The Deterrent Burning Ground and Existing Landfill are located approximately two-thirds and three-fourths of a mile east of the Johnstown Moraine, respectively, in the northeastern quadrant of BAAP. The sites are separated by approximately 1,300 feet and share similar geologic and hydrogeologic settings. To generate a more comprehensive regional understanding, the two sites are described together in the following subsections that summarize information presented in the Final RI Report (ABB-ES, 1993a).

### 4.2.1 Site Surface Water Hydrology

The Deterrent Burning Ground currently occupies a small isolated depression of approximately 2 acres. The depth of the Deterrent Burning Ground pit ranges from 10 to 30 feet bgs. Surface drainage is contained within the isolated pit or is routed to the south, where it enters drainage ditches at the road south of the site. A small drainage ditch south of the Deterrent Burning Ground extends southward where it forms the main drainage ditch transporting water from the Nitroglycerine Pond and Rocket Paste Area south to the Settling Ponds and Spoils Disposal Area. Runoff from the Deterrent Burning Ground area either infiltrates along the ditches or evaporates.

The Existing Landfill, occupying approximately 15 acres, has a vegetated surface with an approximate 4 percent surface slope to the north. Surface drainage from the landfill is routed to the northeast beyond the BAAP boundary to a large kettle depression, where water percolates into the soil and either evapotranspirates or

infiltrates to the water table. The landfill was capped to reduce the amount of infiltrating precipitation.

### 4.2.2 Site Geology

Soil borings and monitoring wells installed at the Deterrent Burning Ground and Existing Landfill encountered approximately 200 feet of unconsolidated soils. A fine-grained layer of silt (i.e., loess) occurs at the ground surface. This is underlain by variably textured sand and gravel with discontinuous gravel layers at depths of approximately 50 to 100 feet bgs. Near the water table, a clayey silt to silty fine sand unit was observed. This fine-grained unit appears more discontinuous and coarser textured in the vicinity of the Existing Landfill than in the vicinity of the Deterrent Burning Ground. Finally, coarser textured sands and gravels were encountered beneath the clayey silt unit.

A dark brown to black organic-rich topsoil has developed at the ground surface over the loess that covers much of the site. Boring logs generally indicate this 2-to-8-foot-thick loess unit is a cohesive brown-to-gray silt and clay with some interbedded sands near the bottom of the unit. The loess appears to be fairly continuous over the area, except for the disturbed and filled areas of the Deterrent Burning Ground and Existing Landfill, where surficial soil was excavated before placement of waste fill and other soil materials.

Variably textured sands and gravels were encountered beneath the loess and fill deposits at the Deterrent Burning Ground and Existing Landfill. These materials are typically characterized as poorly sorted sands and gravels in the upper portions of the unit. With increasing depth, the unit generally changes to well-sorted sands and gravels. Substantial quantities of silty sands also were encountered within these units. This sequence appears to reflect reworked glacial till and glaciofluvial deposits.

Below the reworked deposits, a coarse gravel layer was generally observed at a depth of 50 to 80 feet bgs near the Deterrent Burning Ground, and was occasionally encountered beneath the Existing Landfill. This soil appears to be composed largely of glacial outwash and glaciofluvial deposits.

A fine-grained clayey silt unit (glaciolacustrine) was encountered at a depth of 100 to 170 feet bgs. This unit appears to be laterally extensive in the northern portion of BAAP east of the terminal moraine. At the Deterrent Burning Ground, the glaciolacustrine unit was typically described as a gray silty clay and clayey silt, with

a top surface elevation of 750 to 800 feet above MSL and a total thickness of 3 to 25 feet. The glaciolacustrine unit is less well-defined in the area of the Existing Landfill and appears to grade from a clayey silt to a silty sand from west to east, with a total thickness of 5 to 15 feet. This unit was not clearly encountered to the southeast of the Existing Landfill, where fine lacustrine soils appear to grade to fine silty sands approximately 25 feet higher in elevation. The top surface contours of the glaciolacustrine layer indicate a general anticlinal form with the axis trending generally north-south through the east-central portion of the Deterrent Burning Ground which generally provides a basis to interpret the hydrogeological data.

Beneath the glaciolacustrine unit, deposits of coarse-grained sand and gravel were encountered. Generally, these deposits were described as poorly graded to well-graded gravels with sand. Based on the absence of silty zones, these materials appear to be composed of glacial outwash and glaciofluvial deposits. The location and orientation of geologic cross sections at the Deterrent Burning Ground are shown in Figure 4-3, and representative geologic cross sections are shown in Figures 4-4 and 4-5.

Bedrock was not encountered in borings at the Deterrent Burning Ground or Existing Landfill. However, based on bedrock depths encountered in BAAP Production Well Nos. 1 through 5 and nearby private wells, bedrock is estimated at an approximate elevation of 650 to 700 feet above MSL.

### 4.2.3 Site Hydrogeology

Hydrogeologic conditions at the Deterrent Burning Ground and Existing Landfill are controlled largely by the underlying geologic sequence. As described in the previous subsection, a silty loess soil occurs over the site. Based on laboratory conductivity testing of this layer, it is estimated this unit could limit the amount of precipitation recharging groundwater to approximately 5 to 7 inches per year.

Groundwater that has percolated through the loess must pass through the thick, unsaturated sand and gravel layer beneath. The sand and gravel layer, varying in texture, is approximately 110 to 130 feet thick.

The glaciolacustrine unit located below the sand and gravel layer appears to restrict the vertical flow of groundwater, and the anticlinal slope defined in the previous subsection results in an elevated aquifer with an altered flow direction below the Deterrent Burning Ground (Figure 4-6). Based on groundwater levels in wells

screened in and above the glaciolacustrine unit, it appears the elevated water table at the Deterrent Burning Ground is up to 6 feet higher than would be expected based on the regional water table elevation. Water levels beneath the Existing Landfill appear to be elevated approximately 2 feet above the regional water table. South and east of the Existing Landfill, water table elevations do not appear to be substantially elevated above expected regional levels. The glaciolacustrine unit in this area has a fine sandy texture that apparently does not sufficiently impede the downward vertical movement of recharging groundwater to support a measurable elevated water table.

Figure 4-7 illustrates a contour plan for the regional groundwater flow system. This plan was generated using water levels from monitoring wells located throughout the northeast region of BAAP and Formerly Used Defense Sites (FUDS) wells located east of BAAP. This plan was generated using data from wells screened across the water table. As such, it shows how the elevated flow system is superimposed on the regional system. This illustrates the conceptual model of a localized elevated water table underlain by a fine glaciolacustrine unit and then a deeper regional groundwater flow system.

The primary concern regarding deep groundwater flow in this region is whether groundwater from the elevated system, containing site-related contaminants (principally SO4), recharges the deep regional flow system and migrates to residential wells located on Badger Road (the Spear well) as well as Wiegand's Bay on Lake Wisconsin. To more precisely assess groundwater elevations in the vicinity of Wiegand's Bay, the FUDS program has installed a series of piezometers along Highway 78 east of BAAP (see Final RI Report, ABB-ES, 1993a).

Analysis of the groundwater and surface water elevation data in addition to water quality data indicate migration of groundwater containing site-related contaminants to Wiegand's Bay is unlikely unless water levels in Lake Wisconsin are allowed (by WP&L operators of the dam at Prairie du Sac) to drop below the normally maintained level of elevation 774 feet MSL for prolonged periods of time. The analysis indicates that groundwater within and adjacent to BAAP flows across BAAP. The analysis also indicates that during periods of low groundwater elevation and high surface water elevation, Wiegand's Bay has water levels above the surrounding aquifer and therefore may act as a groundwater recharge zone. Conversely, during periods of high groundwater elevation and low surface water elevation, Wiegand's Bay has water levels below the surrounding aquifer and therefore may act as a groundwater discharge zone.

These results suggest a transient condition with a potential for water to flow both out of the aquifer, into the reservoir, and out of the reservoir into the aquifer. However, it appears that the portion of the aquifer contributing groundwater to Wiegand's Bay is directly north of Wiegand's Bay extending west to an area approximately 1,000 feet east of the BAAP boundary.

## 4.3 CONTAMINATION ASSESSMENT SUMMARY

The soil and groundwater contamination assessment summary is based on data presented in the Final RI Report (ABB-ES, 1993a).

### 4.3.1 Contamination Assessment - Surface Soil

No surface soil samples were collected at either the Deterrent Burning Ground or the Existing Landfill. Soil borings were made in selected locations (Figure 4-1) at the Deterrent Burning Ground, and surface soil concentrations were estimated based on analytical results from samples collected between zero and 2 feet bgs.

### 4.3.2 Contamination Assessment - Subsurface Soil

Subsurface soil samples were collected from the Deterrent Burning Ground borings to identify possible sources of groundwater contamination, characterize the probable extent of the source areas, and evaluate the extent of chemical migration. Analytical results are presented in the Final RI Report (ABB-ES, 1993a).

C6H6 was the principal VOC detected in borings at the Deterrent Burning Ground with the most frequent detections and highest concentrations encountered in boring DBB-91-01. Figure 4-8 shows the vertical extent of contamination of C6H6 in each of the three borings at the Deterrent Burning Ground. C6H6 was used in the DNT extraction process at the facility, and is also likely present as a component of fuels reportedly used to initiate combustion of deterrents. MEC6H5, 1,3-dimethylbenzene (13DMB), and xylene (XYLEN) (fuel-related VOCs) were detected in borings at the Deterrent Burning Ground.

The predominant SVOCs detected at the Deterrent Burning Ground include 24DNT, 26DNT, NNDPA, diethylphthalate (DEP), 3-nitrotoluene (3NT), and DNBP, with minor amounts of B2EHP, fluoranthene (FANT), pyrene (PYR), and phenanthrene (PHANTR). DBB-91-01 had the highest contaminant concentrations of the three

borings. The overall results support the understanding that these locations were used for burning deterrent. Figures 4-9 and 4-10 show the extent of vertical contamination for total DNTs and NNDPA, respectively.

Total metals were analyzed in all subsurface soil samples from the Deterrent Burning Ground. The analyses were for the Priority Pollutant metals, which include silver (AG), AS, BE, CD, CR, CU, PB, HG, nickel (NI), antimony (SB), thallium (TL), and ZN. These analyses indicated concentrations below certified reporting limits or within background conditions for BAAP with two exceptions: PB at a depth of 6 feet bgs in boring DBB-91-01 was detected at 20.2 $\mu g/g$, which is above the maximum site-specific background level of 15.7 $\mu g/g$; and ZN was detected at a depth of 102 feet bgs in boring DBB-91-03 at 106 $\mu g/g$, which is above the site-specific maximum of 81 $\mu g/g$.

NIT and SO4 were analyzed in subsurface soil samples from the Deterrent Burning Ground. NIT results were above the maximum site-specific background level of 4 $\mu g/g$ in each of the three borings; however, the maximum concentration detected was 18.7 $\mu g/g$ and indicates no significant NIT contaminant source. SO4 results were generally below certified reporting limits in samples from DBB-91-01 and -02, although it was detected in samples collected near the water table. At DBB-91-03, SO4 was detected in samples collected between 20 and 122 feet bgs. No known source is attributable to these concentrations, although substantial SO4 concentrations (up to 630,000 $\mu g/L$) have been detected in monitoring wells in this area. The Final RI Report states that the lack of SO4 in subsurface soils suggests that SO4 has either been leached from the soil or did not originate at this location. SO4 could have been transported via groundwater or the unsaturated soils to this area from the filled portion of the Deterrent Burning Ground west of the current pit location. This hypothesis is supported by the higher concentrations and greater vertical distribution of SO4 in boring DBB-91-03, which was drilled to the west and closer to the filled portion of the Deterrent Burning Ground than borings DBB-91-01 and DBB-91-02.

### 4.3.3 Contamination Assessment - Groundwater

Existing and recently installed wells were sampled and analyzed twice during the RI. For an analyte to be considered representative of site conditions, it must have been detected in both rounds of sampling at a given well. Most site-related contaminants detected in groundwater occurred in the elevated flow system and are primarily limited to 1,1,2-trichloroethane (112TCE), 26DNT, SO4, and NIT.

As stated in previous subsections, groundwater in the locally elevated flow system beneath the Deterrent Burning Ground flows east-northeast toward the Existing Landfill. Data indicate that releases of site-related chemicals from the Deterrent Burning Ground affect this elevated groundwater zone. Impact on the deeper regional aquifer, which flows southeast beneath the glaciolacustrine sediments, appears minimal. The compound most clearly showing the characteristics of a groundwater plume at this site is SO4. SO4 has been detected at elevated concentrations, above the WPAL and WES, in a series of wells screened in the locally elevated flow system from the Deterrent Burning Ground to the northeast BAAP facility boundary. 111TCE has been detected in the same area; however, 111TCE has a less extensive plume. 26DNT and NNDPA have been detected within the SO4 plume boundary, but appear to be confined largely to the area of the Deterrent Burning Ground. 26DNT was detected in two samples and NNDPA in three samples.

NIT concentrations exceeding the WPAL occur in many wells although the levels do not exceed the WES. The presence of NIT could be due to the current and past use of nitrate fertilizers in the agricultural areas.

High concentrations of SO4 in groundwater could result from disposal of wastes such as neutralization sludge associated with sulfuric acid (used in the nitration process) or ash from the on-site power plants. The high concentrations of SO4 in groundwater begin at DBM-82-02, located on the northern edge of the Deterrent Burning Ground. Based on subsurface soil chemical data, groundwater chemical data, and groundwater flow direction in the elevated flow system, the Deterrent Burning Ground appears to be the source of SO4 detected in groundwater. However, it is possible that the Existing Landfill is contributing a small percentage of SO4 detected in groundwater.

As described, geologic conditions suggest that fine-grained lacustrine soils, which are responsible for the presence of the locally elevated flow system at the Deterrent Burning Ground, become more discontinuous with a coarser texture to the east. These changes appear to allow the locally elevated flow system to dissipate in this area (i.e., leakage or downward flow to recharge the deeper regional flow system). At ELM-91-10, it appears that mixing of the locally elevated flow system with the regional flow system results in the lower SO4 concentrations. Water from the locally elevated flow system containing higher SO4 concentrations migrating to and mixing with water from the regional system may be diluted as the regional groundwater, which contains lower SO4 concentrations, flows south and southeast through the area.

Concentrations of metals in groundwater samples were within background concentrations, except for CR. CR was detected in most of the wells in Round One, but appeared in only two wells in Round Two. Potential sources of laboratory contamination and error were investigated, but no sources were found to explain these CR data. In addition, field records were checked and standard field sampling practices were followed during both rounds of groundwater sampling. The high CR results in Round One appear to represent laboratory bias (see Subsection 7.4.2.4.5 of the Final RI Report, ABB-ES, 1993a).

Concentrations of BE above the proposed WPAL of 0.4 $\mu$g/L were detected in 8 of 25 wells. BE was detected in Round Two samples only.

### 4.4 Development of Remedial Action Objectives

The baseline risk assessment for the Deterrent Burning Ground and Existing Landfill, as presented in the Final RI Report, included an environmental assessment and a human health evaluation (ABB-ES, 1993a). Subsequent to the finalization of the RI Report, numeric soil clean-up standards for AS, CD, CR, and PB based on human health risk and numeric soil clean-up standards for C6H6, 12DCLE, ETC6H5, and TXYLEN based on protection of groundwater have been presented in the proposed Chapter NR 720. For human health risk, two separate sets of clean-up standards are provided; non-industrial and industrial land use. Procedures for calculating clean-up standards for chemicals without listed numeric standards and procedures for calculating alternative clean-up standards are also included in the proposed Chapter NR 720. Applying the lowest of the human health (assuming industrial land use) and protection of groundwater standards from the proposed Chapter NR 720 for each COC results in soil clean-up levels that are more stringent than those calculated using the criteria used in the baseline risk assessment for human health. Consequently, Deterrent Burning Ground soil clean-up levels for protection of human health and protection of groundwater were developed using criteria in the proposed Chapter NR 720. Soil clean-up levels for protection of ecological receptors were developed using the original risk assessment criteria contained in the Final RI Report.

This subsection presents the COCs identified in the Final RI Report and summarizes the risks to ecological and human receptors. The remedial action objectives developed in this subsection, which incorporate cleanup standards, are designed to reduce the risks posed by site contaminants to acceptable levels.

### 4.4.1 Summary of Human Health Evaluation

Subsurface soil and groundwater are the contaminated media to which humans may be exposed at the Deterrent Burning Ground and Existing Landfill. The exposure scenario (provided in the proposed Chapter NR 720) evaluated at the Deterrent Burning Ground was incidental ingestion of subsurface soil and inhalation of particulate matter for an adult worker. Because BAAP is currently in standby status and will be government-owned for the foreseeable future, residential exposures will not occur. Therefore, the non-industrial exposure scenario provided in the proposed Chapter NR 720 was not evaluated.

In addition to evaluating the human health risks from exposure to contaminated soil, the potential for contaminants leaching from subsurface soil and degrading groundwater quality in excess of WPALs was evaluated per the proposed Chapter NR 720.

Although scenarios associated with exposure to Deterrent Burning Ground groundwater were not evaluated, groundwater quality was compared to state and/or federal groundwater standards or risk-based concentrations.

**4.4.1.1 Selection of Human Health Chemicals of Concern.** HCOCs are chemicals, with inherent toxic/carcinogenic effects, that are likely to pose the greatest threat to human receptors. Based on the frequency of occurrence, the range of concentrations compared to background levels, and other screening criteria, HCOCs were selected and presented in Table 4-1.

**4.4.1.2 Human Health Risk Characterization.** Soil clean-up standards calculated using procedures outlined in the proposed Chapter NR 720 that represent acceptable levels of and/or noncarcinogenic risk from subsurface soil contaminants are presented in Table 4-2. Potential human receptors are expected to be at risk from 24DNT, 26DNT, NNDPA, and AS in subsurface soil. Soil clean-up standards protective of groundwater are also presented in Table 4-2.

Soil contaminants which are currently a potential threat to groundwater quality are 24DNT, 26DNT, AS, and CR. Leaching models were developed following the procedures outlined in the proposed Chapter NR 720, and all HCOCs were modeled to determine if the concentrations of the HCOCs in subsurface soils would potentially result in exceedances of WPALs in groundwater. For organic contaminants, leaching model parameters included the partitioning between soil and

water, volatilization, and degradation during migration. For metals, the only leaching model parameters included the partitioning between soil and water during migration. No modeling was attempted for anionic HCOCs (i.e., NIT and SO4) because no models exist to predict concentrations during migration of these contaminants.

Contaminant concentrations in groundwater exceed groundwater standards or calculated risk-based levels. Table 4-3 summarizes the chemicals detected in the groundwater, the frequency of detection, and the minimum and maximum detected concentrations. Concentrations of 26DNT, 112TCE, NNDPA, CR, HG, and NIT exceed MCLs or WESs. Concentrations of barium (BA), CD, and PB, are below standards but exceed WPALs. Concentrations of BE are below the interim WESs, but exceed the interim WPALs. Concentrations of MN and SO4 exceed secondary drinking water standards, while NA exceeds a reporting level for sodium-restricted diets. Although there are no promulgated Wisconsin for BE and NNDPA, WDNR has established interim WESs and WPALs for BE and NNDPA. Federal criteria for BE is 4 $\mu$g/L. The maximum concentration of NNDPA exceeds its interim WES and the maximum concentration of BE exceeds its interim WPAL.

### 4.4.2 Summary of Baseline Ecological Assessment

No permanent water bodies or wetland areas are associated with the Deterrent Burning Ground. As a result, only terrestrial organisms will likely be exposed to contamination in the area. Surface soil (i.e., zero to 2 feet bgs) is the only medium to which terrestrial organisms may be exposed. Incidental soil ingestion and consumption of contaminated food are the likely exposure pathways for these potential receptors.

**4.4.2.1 Selection of Ecological Chemicals of Concern.** ECOCs are chemicals with inherent toxic/carcinogenic effects that are likely to pose the greatest threat to ecological receptors. No surface soil data, other than a single soil boring sample (collected at 2 feet bgs), are available for the Deterrent Burning Ground. The Existing Landfill was capped and closed in 1989; therefore, it is unlikely that ecological receptors would be exposed to any surface contamination. As a result, no ECOCs were selected for the Deterrent Burning Ground.

**4.4.2.2 Ecological Risk Characterization.** The deterrent burning pits are covered with plastic and backfilled with soil. The only surface soil data available for the Deterrent Burning Ground is from a sample collected at a depth of 2 feet at DBB-91-01. Although some burrowing animals and soil invertebrate fauna may be exposed

to soil contamination at this depth, it is inappropriate to conduct a quantitative assessment on such limited data. 24DNT was detected at a concentration of 2,700 $\mu g/g$ in this sample and ecological receptors could be at risk from this compound if this concentration is representative of general conditions.

### 4.4.3 Identification of Remedial Action Objectives - Surface Soil

Because the waste pits at the site have been covered with plastic and backfilled with non-site-related soil, risks from exposure to surface soil were not evaluated. Therefore, no remedial action objectives were chosen for surface soil.

### 4.4.4 Identification of Remedial Action Objectives - Subsurface Soil

There are no ecological risks associated with subsurface soil. The human health evaluation indicates the concentrations of 24DNT, 26DNT, AS, and NNDPA in subsurface soil exceed clean-up standards for protection of human health developed and/or obtained from the proposed Chapter NR 720.

In addition to excessive risks to human health, soil leaching models indicate that 24DNT, 26DNT, AS, and CR in subsurface soil exceed clean-up standards for protection of groundwater, also developed from the proposed Chapter NR 720. This subsection identifies the remedial action objectives that would reduce the human health risks associated with contaminated soil to acceptable levels, and reduce the potential for further degradation of groundwater quality from subsurface soil contaminants leaching into groundwater.

Based on site conditions, the nature of contaminants, the migration pathways, and the conclusions of the human health risk characterization, the following remedial action objective for subsurface soil has been formulated:

- Prevent concentrations of 24DNT, 26DNT, NNDPA, and AS in subsurface soil which exceed clean-up standards for protection of human health (developed and/or obtained from the proposed Chapter NR 720) from becoming available, either through incidental ingestion of soil or inhalation of particulates, to potential human receptors.

- Prevent concentrations of 24DNT, 26DNT, AS, and CR which exceed clean-up standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality.

Table 4-4 lists the contaminants in subsurface soil to be addressed during remediation, detection limits, maximum detected concentrations at the Deterrent Burning Ground, maximum background concentrations for metals, clean-up standards for the protection of human health and groundwater (developed and/or obtained from the proposed Chapter NR 720), and the recommended remediation goal with associated rationale. The maximum background concentrations are either the BAAP or the regional background concentrations presented in the Final RI Report, which ever is the greatest.

Table 4-4 indicates that the detection limit has been selected as the remediation goal for 24DNT. The detection limit is greater than the clean-up standard developed for this contaminant therefore the remediation goal could result in inadequate protection for human receptors and/or groundwater quality. However, if remediation goals are set below detection limits they would be unmeasurable and would probably be unattainable by most (if not all) existing soil remediation technologies.

Table 4-4 also indicates that the maximum background concentrations have been selected as the remediation goals for AS and CR. Although background concentrations of AS and CR exceed clean-up standards for protection of groundwater, there would be no significant benefit to the regional aquifer by remediating subsurface soil within small isolated areas to below background concentrations.

### 4.4.5 Identification of Remedial Action Objectives - Groundwater

There are no ecological risks associated with groundwater. The human health risk characterization indicates the following:

- Concentrations of 26DNT and 112TCE exceed WESs;

- Concentrations of NIT, CR, and HG exceed both MCLs and WESs;

- Concentrations of BA, CD, and PB are below WESs but exceed WPALs;

- Concentrations of BE and NNDPA exceed the interim WPAL standard of 0.4 $\mu$g/L and 0.7 $\mu$g/L, respectively;

- Concentrations of MN and SO4 exceed secondary drinking water standards; and

- Concentrations of NA exceed the level considered protective of receptors on sodium-restricted diets.

Based on the site conditions, nature of the contaminants, migration pathways, and conclusions of the human health risk characterization, the following remedial action objectives for groundwater have been formulated:

1) Prevent further contamination of the elevated groundwater system.

2) Prevent exposure to concentrations of 26DNT, 112TCE, NIT, BA, CR, HG, CD, and PB exceeding their respective WPALs.

3) Prevent exposure to concentrations of BE and NWDPA above interim WPAL standard of 0.4 $\mu$g/L and 0.7 $\mu$g/L, respectively.

4) Prevent exposure to concentrations of MN and SO4 exceeding secondary drinking water standards.

Table 4-5 presents the contaminants in groundwater requiring remediation, the selected remediation goal with associated rationale, and maximum reported concentrations of chemicals in groundwater at Deterrent Burning Ground (DB-series) monitoring wells.

The prevention of exposure to 26DNT, 112TCE, NNDPA, NIT, BA, CD, PB, CR, and HG at concentrations exceeding their respective WPALs will result in levels protective of human health. As stated in Subsection 2.6, chemical-specific ARARs are generally health- or risk-based and represent an acceptable concentration of that chemical in environmental media. The WPAL is the chemical-specific ARAR selected as the remediation goal for groundwater, because it is a promulgated standard and is more stringent than the MCL for each of these contaminants except 26DNT and NNDPA, which have no assigned MCL.

Remedial action objectives for NIT in groundwater are not being proposed, as explained in Subsection 3.4.5, where a similar development of objectives for groundwater at the Propellant Burning Ground site is presented. Given the current and past use of nitrate fertilizers in regional and local agricultural areas, the relatively high background concentrations of NIT in groundwater (i.e., background range of 75 to 10,000 $\mu g/L$ compared to the reported range of 130 to 16,000 $\mu g/L$) in the vicinity of the Deterrent Burning Ground, and the low potential for exposure in this area, an exemption from the WPAL for NIT is appropriate.

The prevention of exposure to BE and NNDPA concentrations exceeding their respective interim WPALs will result in levels protective of human health. The Wisconsin Department of Health and Social Services, Division of Health, established the interim state drinking water standards to use until final standards for BE and NNDPA are promulgated.

The prevention of exposure to MN and SO4 concentrations exceeding their respective drinking water standards will result in acceptable protection against exposure to groundwater exceeding aesthetic quality-based standards.

Although the maximum reported concentration of NA at the Deterrent Burning Ground exceeds the MCL of 20,000 $\mu g/L$, no remedial action objective is proposed for the reasons stated in Subsection 3.4.5 where the objectives for Propellant Burning Ground groundwater are presented. The MCL for NA is a reporting level; the regulatory requirement is monitoring and reporting analytical data to WDNR to protect individuals on sodium-restricted diets. Monitoring and reporting NA concentrations in groundwater will occur during implementation of the remedial action objectives for groundwater.

## 4.5 Identification and Screening of Applicable Remedial Technologies

This subsection identifies and screens applicable technologies for soil at the Deterrent Burning Ground. The result of the screening is a list of applicable technologies that are retained for the development of remedial alternatives.

Treatment technologies were identified using the BAAP Remedial Technology Handbook, review of other available technology literature, vendor information, and previous feasibility and design experience. As the Remedial Technology Handbook

was developed specifically for contaminants at BAAP, it was used as the primary source for technology identification.

The identification process considered both the specific site and waste characteristics. Waste characteristics included the following:

- type of contaminants
- contaminant concentrations
- physical and chemical properties of the contaminants (e.g., volatility, solubility, and mobility)

Site characteristics considered included the following:

- site geology, hydrogeology, and topography
- space and resource restrictions associated with implementation of a technology
- the presence of any special site features or restrictions (e.g., pavement, buildings, underground utilities)

In the screening process, the number of identified technologies was reduced by evaluating the advantages and disadvantages of each technology with respect to the technology's effectiveness and implementability. The technologies retained for alternative identification were those with the potential to effectively remediate the site, either alone or with other technologies. The process used for the technology screening phase is consistent with the USEPA RI/FS Guidance document (USEPA, 1988b).

### 4.5.1 Remedial Technology Identification and Screening for Soil

This subsection identifies and screens remedial technologies for subsurface soil at the Deterrent Burning Ground using the criteria discussed above.

**4.5.1.1 Remedial Technology Identification - Soil.** Remedial technologies applicable to the Deterrent Burning Ground are identified in Table 4-6. The table also

identifies the general response actions associated with the technology, followed by a brief description.

**4.5.1.2 Remedial Technology Screening - Soil.** The screening of technologies is shown in Table 4-7. Those technologies considered not effective or implementable were eliminated from further consideration. Table 4-8 lists those technologies retained and subsequently used to develop remedial alternatives.

### 4.5.2 Remedial Technology Identification and Screening for Groundwater

This subsection identifies and screens remedial technologies for groundwater at the Deterrent Burning Ground using the criteria discussed above.

**4.5.2.1 Remedial Technology Identification - Groundwater.** Table 4-9 identifies general response actions potentially applicable to the Deterrent Burning Ground groundwater.

**4.5.2.2 Remedial Technology Screening - Groundwater.** Technology screening is shown in Table 4-10. Those technologies considered not effective or implementable were eliminated from further consideration. Those technologies remaining after screening, summarized in Table 4-11, were subsequently used to develop remedial alternatives.

## 4.6 DEVELOPMENT AND INITIAL SCREENING OF REMEDIAL ALTERNATIVES

In this subsection, technically feasible remedial technologies for soil are assembled into remedial alternatives. The remedial alternatives presented here are screened based on their effectiveness, implementability, and cost. Alternatives retained for detailed analysis include minimal action, containment, and treatment alternatives. The selection of alternatives is also consistent with Section 300.430(e) (3) of NCP, which requires evaluation of a range of remedial alternatives (i.e., from alternatives that remove or destroy contaminants to the maximum extent feasible, to alternatives that provide little or no treatment but provide protection of human health and the environment) (USEPA, 1990).

For the purposes of alternatives development and screening, soil at the Deterrent Burning Ground can be defined as subsurface soils (from zero to 15 feet bgs). The primary contaminant of concern in the soil is DNT and the remedial actions

associated with the soil are to reduce direct contact and ingestion risks as well as diminish the potential for exposure to groundwater contamination.

### 4.6.1 Remedial Alternatives Development and Initial Screening for Soil

This subsection describes the remedial alternatives for soil at the Deterrent Burning Ground.

**4.6.1.1 Development of Remedial Alternatives - Soil.** Eight remedial alternatives were developed for the treatment of soils at the Deterrent Burning Ground. These include one minimal action alternative, one containment alternative, one excavation/disposal alternative, and five treatment alternatives. Table 4-12 identifies these alternatives as well as the technologies that make up their components. Table 4-13 provides descriptions of the key components in each of the alternatives; a general discussion is provided in the following paragraphs.

Minimal Action. The minimal action alternative, DBG-SB1, does not provide containment or treatment of contaminants. This alternative includes measures to prevent human exposure. Institutional controls such as zoning and deed restrictions, as well as education programs, would provide protection. Because the contaminants remain on site, this alternative would include groundwater monitoring and recommended five-year site reviews.

Containment. The containment alternative, DBG-SB2, was developed to reduce the potential mobility of contaminants and to reduce exposure to contaminants. A RCRA cap would provide an increased level of protection over that provided by the minimal action alternative. The RCRA cap would prevent direct contact with the contaminants, leaching of contaminants to groundwater, and also preventing contaminant migration off site via soil erosion. Groundwater monitoring and five-year reviews would be included with this alternative.

Excavation/Disposal. The excavation/disposal alternative, DBG-SB3, also reduces the potential mobility of site contaminants and receptor exposure to contaminated soil. This alternative would remove contaminants and their associated risks from the site for disposal in an off-site, RCRA-permitted landfill. Groundwater monitoring and five-year site reviews would not be included with this alternative.

Treatment. There are five alternatives listed under this heading as follows:

- DBG-SB4: Soil Washing. This alternative would reduce contaminants on site. The contaminants would be concentrated to a fraction of their original volume and transported off site. The soil remaining on site would be used as backfill for the excavations. Groundwater monitoring and five-year site reviews are not included because contaminants are removed from the site.

- DBG-SB5: Off-Site Incineration. This alternative would result in a reduction of on-site contaminants. The contaminants would be transported off site and incinerated; the excavations would be backfilled with clean fill. No long-term management would be required.

- DBG-SB6: Off-Site Incineration, Soil Washing. This alternative uses a combination of the two technologies. In this alternative, "hot-spot" soils (>10,000 $\mu g/g$ DNT) would be taken to an off-site incinerator and the remaining contaminated soil would be treated by soil washing. This would reduce the contaminant volume being transported and treated off site and reduce the number of washings required by incineration or soil washing alone. The soil remaining on site would be used, along with clean fill, to backfill excavations. Contaminants are removed and, therefore, the alternative does not include long-term management.

- DBG-SB7: On-Site Incineration. This alternative would again reduce soil contaminants remaining on site. Contaminants would be concentrated in a fraction of their original volume and disposed of off site. The soil remaining on site would be used as backfill. No long-term management is included because the contaminants would be removed from the site.

- DBG-SB8: Composting. This alternative would reduce contaminants on site. The contaminants would be reduced on site to levels protective of human health by biodegradation. The treated soils would be used as backfill for excavations. Groundwater monitoring and five-year site reviews are not included because contaminants are destroyed.

**4.6.1.2 Initial Screening of Remedial Alternatives - Soil.** The eight remedial alternatives were screened on a basis of effectiveness, implementability, and cost. Components considered for each of the evaluation criteria are presented in Figure 1-5. Table 4-14 presents the screening process for each alternative. A summary of the alternatives showing the status of each based on initial screening is presented in Table 4-15.

### 4.6.2 Remedial Alternatives Development and Initial Screening for Groundwater

Six remedial alternatives were developed for groundwater at the Deterrent Burning Ground. These include a minimal action alternative and five treatment alternatives. Table 4-16 identifies these alternatives and the technology components. Table 4-17 provides further details of the key components. The treatment alternatives mirror those at the Propellant Burning Ground. The contaminants are similar and with the low volumes and flow rates expected from the elevated aquifer, any groundwater extracted from the Deterrent Burning Ground will be transported to the Propellant Burning Ground. If a treatment alternative is chosen at the Deterrent Burning Ground, it will be the same as what is chosen at the Propellant Burning Ground. A general discussion of the alternatives is provided in the following paragraphs.

<u>Minimal Action</u>. The minimal action alternative, DBG-GW1, does not include containment or treatment of contaminants. This alternative includes measures to prevent human exposure to groundwater contaminants. Institutional controls such as zoning and deed restrictions, as well as educational programs, would reduce the potential for human exposure to contaminated groundwater. Because contaminants would remain in the aquifer for an indefinite period, long-term management in the form of groundwater monitoring and five-year site reviews is included.

<u>Treatment</u>. Five alternatives were developed to treat Deterrent Burning Ground groundwater. The alternatives include groundwater extraction and discharge of treated groundwater to Lake Wisconsin. The treatment alternatives parallel those developed for the Propellant Burning Ground in Section 3.0, because the alternatives include transporting extracted Deterrent Burning Ground groundwater to the eventually selected IRM treatment system. They are listed below:

- DBG-GW2: IRM and Carbon Adsorption. This alternative includes groundwater extraction from the Deterrent Burning Ground, and use of the existing IRM facility and a new carbon adsorption facility for treatment, with discharge to Lake Wisconsin. The treatment of

extracted groundwater includes carbon adsorption followed by air stripping in the IRM facility. Extracted groundwater would be transported by truck to the existing facility.

- DBG-GW3: IRM and UV/Oxidation. This alternative would include groundwater extraction and transport from the Deterrent Burning Ground to the IRM facility and the new treatment facility at the Propellant Burning Ground. UV/Oxidation would destroy the contaminants in the waste stream from the Deterrent Burning Ground.

- DBG-GW4: IRM and Air Stripping - Carbon Adsorption. Groundwater would be extracted from the Deterrent Burning Ground and transported to the IRM facility and the new treatment facility at the Propellant Burning Ground. Air stripping would remove the bulk of any volatile contaminants, and carbon adsorption would function to polish the effluent. Air stripping is not considered particularly effective for DNTs, but will remove volatile organics without loading up the carbon, which removes DNTs.

- DBG-GW5: IRM and Resin Adsorption. This alternative would include transporting extracted groundwater to the IRM facility and new treatment facility at the Propellant Burning Ground. The resin in this treatment alternative is capable of treating all the contaminants in the waste stream. However, considerable time and expense would be spent in treatability studies to identify a suitable resin.

- DBG-GW6: IRM and UV/Reduction - Carbon Adsorption. This alternative would include transporting extracted groundwater to the IRM facility and the new treatment facility at the Propellant Burning Ground. UV/Reduction would destroy the chlorinated compounds in the groundwater and partially destroy DNTs. The remaining DNTs would be removed by carbon adsorption.

### 4.6.3 Initial Screening of Remedial Alternatives for Groundwater

The six remedial alternatives were screened on a basis of effectiveness, implementability, and cost. Components considered for each of the evaluation criteria are presented in Figure 1-5. Table 4-18 presents the screening process for

each alternative. A summary of the alternatives showing the status of each based on initial screening is presented in Table 4-19.

## 4.7 Summary of Contamination Assessment through Remedial Alternatives Screening

A summary of RI/FS components, from identification of contaminants of concern through remedial alternatives retained after screening is presented in Table 4-20.

# 5.0 NITROGLYCERINE POND/ROCKET PASTE AREA

Section 5.0 first summarizes the backgrounds and histories of the Nitroglycerine Pond and Rocket Paste Area (NG/RPA), along with geology and groundwater characterizations, contamination assessments, and baseline risk assessments, as described in Section 8.0 of the Final RI Report (ABB-ES, 1993a). Then, based on the excessive risk to human health and ecological receptors at these sites, this section develops the remedial action objectives and alternatives necessary to address site contamination, and concludes with the screening of remedial alternatives. Alternatives retained after the screening process will be evaluated further in the detailed analysis presented in Section 11.0.

## 5.1 SITE BACKGROUND AND HISTORY

The following subsections describe the backgrounds and histories of the NG/RPA.

### 5.1.1 Nitroglycerine Pond

The Nitroglycerine Pond is a small, unlined basin that previously held cooling water and process wastewaters generated in the NG manufacturing area (Figure 5-1). The NG facility and Rocket Paste production areas are believed to have been constructed in the late 1940s. According to the Olin Point Source Pollution Engineering Study (Olin, 1984), wastewater had been neutralized at the plant before being discharged into the pond. Possibly NG and other contaminants such as NIT, SO4, NA, CA, and chlorides were present in the discharge; however, actual wastewater characterization data are not available. It is believed that HG and PB were also present in the wastewater.

In addition to the main pond, a large, low-lying area immediately east of the pond appears to have received overflow from the pond, possibly during production periods in the 1960s. This overflow pond does not have an outflow channel. The Nitroglycerine Pond is part of the major drainageway from the central manufacturing and storage areas of BAAP. The Nitroglycerine Pond drains south to the Rocket Paste Pond. Water exists in both the main pond and overflow pond throughout the year.

### 5.1.2 Rocket Paste Area

The Rocket Paste Area is located in the central portion of BAAP, immediately south of the Nitroglycerine Facility and east of the Johnstown Moraine (see Figure 5-1). The Rocket Paste Area contains numerous facilities for blending, pressing, milling, and drying rocket paste. The Rocket Paste Area is divided into two sections: The East Rocket Paste Area, active during World War II, and the West Rocket Paste Area, active after World War II. In addition, the Rocket Paste Pond is located in this area and currently only holds water for part of the year.

Rocket paste is double-based plasticized propellant used for solid-fuel rockets. During past propellant manufacturing operations in the north end of the West Rocket Paste Area, waste propellant in the form of a reddish orange paste accumulated in the Rocket Paste Pond. Waste propellent also accumulated in many portions of the drainage ditches. Process wastewaters transported via these ditches consisted of makeup water used in mixing and formulating rocket paste, as well as cooling and washdown water, according to Olin's Point Source Pollution Engineering Study (Olin, 1984). The rocket paste reportedly contained 1.2 percent each of PB salicylate and PB ethylhexoate, in addition to NG and NC (Piercy, 1977). Visible paste was removed and burned at the Propellant Burning Ground after BAAP went on standby status in 1975.

Storm water and process wastewater from the Rocket Paste Area are transported via a series of drainage ditches (see Figure 5-1). In the West Rocket Paste Area, interconnecting drainage ditches transported water and wastewater to a drainageway that extends south through the Magazine Area more than 2 miles to Settling Pond 3 near the southern boundary of BAAP. The MEP describes the Rocket Paste Pond as an unlined catch basin 6 to 12 inches deep that serves as a settling basin for suspended rocket paste particles in the liquid waste streams (Tsai et al., 1988). The pond also received process wastewater from the NG manufacturing area to the north. Effluent from the pond discharges into a ditch which connects with the ditch draining the West Rocket Paste Area. In the East Rocket Paste Area, storm water and process wastewater are transported via interconnected drainage ditches to settling basins located north and south of the East Rocket Paste Area.

According to BAAP, both the West and East Rocket Paste Areas are on standby status. The newer West Rocket Paste area is in much better condition than the East Rocket Paste Area.

## 5.2 GEOLOGY AND GROUNDWATER CHARACTERIZATION

The geologic and hydrogeologic interpretations of the NG/RPA are based on data presented in the Final RI Report (ABB-ES, 1993a).

### 5.2.1 Surface Water Hydrology

The Nitroglycerine Pond area, located east of the Johnstown Moraine, has an irregular surface topography with numerous small hills and isolated depressions. Topographic relief is approximately 30 feet. The natural drainage network is poorly developed except for the man-made drainage ditch transecting the site area from north to south and flowing through the Nitroglycerine Pond (main ditch). This contrasts with conditions at the Rocket Paste Area, also located east of the Johnstown Moraine, where site construction activities leveled the surface topography leaving only a few small hills and a series of human-made drainage ditches.

The principal surface water features in these areas include the Nitroglycerine Pond, Rocket Paste Pond and Overflow Pond, and a series of drainage ditches that flow through the ponds and transect the sites. The Nitroglycerine Pond is a small unlined basin that appears to occupy a preexisting natural depression that was recontoured to meet the needs of the facility. A low area bordering the pond to the east received overflow from the pond during past operations.

The Rocket Paste Pond is another small unlined basin south of the Nitroglycerine Pond. Like the Nitroglycerine Pond, the Rocket Paste Pond appears to occupy a natural depression modified to meet the drainage needs of the facility. This basin received surface water runoff from the northern portion of the West Rocket Paste Area as well as overflow water from the Nitroglycerine Pond. Both ponds exist as perched water bodies, probably because of the presence of a layer of fine-grained sediments in the bottom of each pond, and contain water most of the year.

Most surface water runoff from the central production and storage facilities of the NG/RPA is routed to a series of man-made drainage ditches that originate near the Deterrent Burning Ground and transect these sites from north to south. Water from the Rocket Paste Pond and West Rocket Paste Area eventually discharges to Settling Pond 3 located along the southern boundary of BAAP. Water from the East Rocket Paste Area discharges to depressions north and south of this area. The man-made drainage ditches were not designed to collect runoff from nonproduction areas.

Runoff from these areas discharges to isolated depressions that are common in the area east of the Johnstown Moraine.

### 5.2.2 Site Geology

Soil borings and monitoring wells installed at the NG/RPA generally have encountered a stratigraphic sequence similar to that observed over much of the area east of the Johnstown Moraine. Unconsolidated soil deposits appear to range between 200 and 250 feet thick and are predominantly variably textured, coarse-grained soils. The locations of monitoring wells installed in this area is presented in Figure 5-2.

Surficial soils in this area are composed of fine-grained loess and granular fill. The loess, composed of windblown fine sand, silt, and clay, is typically accompanied by an overlying organic-rich topsoil. Where encountered in this area, loess was described as reddish-brown to gray clayey silt and fine sand that ranged from 7 to 19 feet thick.

At several locations only granular fill was encountered at the ground surface suggesting that the fine-grained loess and topsoil were removed from these areas during site construction activities. Fill soils were typically described as tan-to-brown, fine-to-coarse sand with little to some gravel, silt and clay, and occasional cobbles.

Underlying the loess and surficial fill soils, variably textured sands and gravels were encountered. At several locations, very coarse gravel, cobble, and boulder zones were encountered immediately below the surface soils. This condition is typical of ablation tills where coarse-grained soils were deposited by melting glacial ice. At other locations, sands and gravels were encountered below the loess. These soils were typically described as light gray-to-brown, medium-to-fine sand with some gravel and silt.

It should be noted that silt and clay layers observed north of this area near the Deterrent Burning Ground (presented in Section 4) were not encountered in borings at the NG/RPA. In addition, water table elevations conform to the regional flow pattern, showing no evidence of a perched or elevated condition. This indicates that clay and silt deposits observed to the north do not extend into this region.

### 5.2.3 Site Hydrogeology

The fine-grained silty loess immediately below the ground surface generally restricts the infiltration of precipitation; recharge to the underlying groundwater flow system is limited to approximately 5 to 7 inches per year. However, where the loess unit has been stripped from the site because of construction activities, infiltration rates and corresponding recharge rates may be higher, approximately 7 to 9 inches per year. Recharge rates could be higher beneath the Nitroglycerine Pond and Rocket Paste Pond, which hold water throughout much of the year.

Underlying the fine-grained surficial soils is a thick sequence of sand and gravel. In this area, the upper 100 to 130 feet of the unit is unsaturated and constitutes a considerable vadose zone. Below the water table, an additional 120 to 170 feet of saturated sand and gravel constitutes the unconsolidated sand and gravel aquifer.

Hydraulic conductivity testing, based on in situ slug withdrawal tests, was performed at several wells in the NG/RPA. The results of tests, indicating a range of hydraulic conductivity from 0.1 to 0.2 cm/sec, are somewhat higher than the average for other tests conducted east of the terminal moraine at BAAP.

Figure 5-3 shows a water table contour plan for the NG/RPA, generally indicating groundwater flow from north to south. The regional water table, as illustrated in Figure 1-4, shows groundwater north of this region flowing to the southeast but turning to the south as it flows through the NG/RPA.

These sites lie at the southern extent of an area of flat water table gradients that occurs throughout much of the northeastern and central portions of BAAP. These flat gradients reflect the influence of the Lake Wisconsin Reservoir located to the east and south. The water table drops only 2.7 feet throughout this area, resulting in a horizontal gradient of 0.0008 ft/ft.

Groundwater flow velocity ranges from 240 to 330 ft/yr. The higher velocities likely reflect conditions associated with more permeable zones, while the lower velocities are likely associated with less permeable zones. Permeability estimates are based on slug test data only; no aquifer tests were performed in this area.

## 5.3 Contamination Assessment Summary

The surface soil, sediment, subsurface soil, surface water, and groundwater contamination assessment summaries are based on data presented in the Final RI Report (ABB-ES, 1993a).

### 5.3.1 Contamination Assessment - Surface Soil/Sediment

Table 5-1 presents the detection frequency and maximum concentrations for all chemicals detected in the surface soil and sediments in the NG/RPA. The following general conclusions are indicated by this table:

- Primarily metals have been detected in the Nitroglycerine Pond, Overflow Pond, and Rocket Paste Pond sediment and in the Nitroglycerine Pond area surface soil,
- SVOCs and metals have been detected in Rocket Paste Area surface soil, and
- In general, compounds are detected at a higher frequency and at higher levels in the Eastern Rocket Paste Area surface soil than in the Western Rocket Paste Area surface soil.

Nitroglycerine Pond. Previous studies of surface soil and sediments in the Nitroglycerine Pond and the Western Rocket Paste Area are summarized in the MEP (Tsai et al., 1988). All previous sediment samples were collected from the drainage ditch connecting these two areas (see Figure 5-1). The following is a summary of the results from this sampling effort.

PB exceeded the extraction procedure toxicity threshold value (EPTOX TV) for two samples just north of the Rocket Paste Pond along the drainage ditch (Daubel, 1986; and Hellewell and Mattei, 1983). The remaining samples were collected further downstream and did not exceed the EPTOX TVs. In three samples, PB extract concentrations exceeded 1,000 milligrams per liter (mg/L). Ayres Associates analyzed samples for 24DNT, 26DNT, DEP, DPA, 2-nitro-n-nitrosodiphenylamine (2NNDPA), NC, and NG, but none of these chemicals were detected (Ayres Associates, 1984).

ABB-ES personnel collected seven sediment samples from the Nitroglycerine Pond, one sediment sample from the Overflow Pond, and two surface soil samples from the Nitroglycerine Pond drainage ditch area (Figure 5-1). These samples were analyzed for total metals (i.e., CD, CR, HG, and PB), NG, and ammonia (NH3). Following is a summary of the results:

- CD was not detected above its background value.
- NG was not detected above the certified reporting limit in the sediment samples. NG was detected in the two surface soil samples collected from the drainage ditch at 9.39 and 15.8 $\mu g/g$.
- NH3 was detected in all samples (concentrations ranging from 2.28 to 72.5 $\mu g/g$).
- HG was detected above background concentrations in all but one of the surface soil and sediment samples, ranging from 0.159 to 20.0 $\mu g/g$. The high HG concentrations were detected in the Nitroglycerine Pond and Overflow Pond sediment samples.
- PB was detected in all sediment samples from 32 to 410 $\mu g/g$. Generally, the detected concentrations were higher at the pond margins than at the center of the pond. PB was detected in the two drainage ditch surface soil samples at 2,000 and 10,000 $\mu g/g$.

**Interpretation** - The primary contaminants detected in Nitroglycerine Pond sediments were NG, HG, and PB. NG is a component of the paste and was manufactured in a batch process in PB tanks. The PB in sediments likely originated from these tanks. HG would be expected because elemental HG was used during the purity testing of NG. Laboratory wastes containing HG from plant activities could have reached the Nitroglycerine Pond and sorbed to the sediments. HG appears bound to the sediment within the pond because it is not detected at NPS-91-10 (#12 in Figure 5-1). However, HG was detected in a TCLP extract sample collected from sediment in the Overflow Pond. NG and PB are found at concentrations in the ditch greater than those detected within the pond sediments, indicating these contaminants could have been partially flushed from the pond. PB concentrations in surface water could reflect partitioning of the PB in sediments.

Rocket Paste Pond. ABB-ES collected two sediment samples from the Rocket Paste Pond and two surface soil samples from the drainage ditch that carries the discharge from the pond into the Western Rocket Paste Area. The samples were analyzed for total and TCLP metals (CD, CR, HG, and PB), NG, NIT, SVOCs, DNTs, and SO4. Following is a summary of the results:

- NG was detected in one sediment sample at 1.76 $\mu g/g$. NNDPA was detected in both sediment samples at 4.98 and 0.738 $\mu g/g$. DEP was detected in one sediment sample at 2.46 $\mu g/g$. No other SVOCs were detected in the sediment samples.

- SVOCs were not detected above the certified reporting limit in the two surface soil samples.

- CD was not detected above the certified reporting limit in either the sediment or surface soil samples.

- CR was detected above background in all four samples. The maximum detected concentration in the sediment samples is 45.7 $\mu g/g$, and in the surface soil samples is 17.4 $\mu g/g$.

- PB was detected above background in all four samples, the maximum concentration detected was 3,500 $\mu g/g$. Three of the four samples exceeded 1,000 $\mu g/g$.

- HG was detected near background levels in the sediment samples and was not detected in the surface soil samples.

- NIT was detected near background levels at all four sample locations. SO4 was detected above background levels at all four sample locations. SO4 was significantly higher in the sediment samples, the maximum concentration being 150 $\mu g/g$.

**Interpretation**. PB was the major contaminant in the Rocket Paste Pond sediments and soils of the main drainage ditch downgradient from the pond. This agrees with the results reported in the MEP (Tsai et al., 1988). PB contamination is most likely caused by the use of PB as a component of rocket paste. Concentrations above background for CR and HG and concentrations of DEP, NG, NIT, NNDPA, and SO4 were detected in sediment and surface soil. All these materials can be

attributed to the chemical compounds used in the rocket paste manufacturing operation. During propellant manufacturing operations, waste propellant in the form of an orange paste accumulated in the Rocket Paste Pond and in the main drainage ditch. In the mid- to late 1970s, sediments were removed as the facility was deactivated. However, some PB contamination remains.

Rocket Paste Area. Twenty-six surface soil samples were collected from drainage ditches in the West Rocket Paste Area. Thirty-eight surface soil samples were collected from the East Rocket Paste Area ditches. Sampling locations are shown in Figure 5-1. These surface soil samples were analyzed for total metals (i.e., CD, CR, HG, PB), NAMs, SVOCs, DNTs, NG, NIT, and SO4.

Generally, the data indicate that NNDPA, NG, 24DNT, and PB are the principal contaminants at this site (Table 5-1). Overall contaminant levels are lower in the West Rocket Paste Area. This likely reflects the excavation of West Rocket Paste area ditches during the 1970s when the facility was deactivated.

NNDPA. NNDPA was the dominant nitrosamine detected and was also the most predominant contaminant detected in surface soils. In many samples, particularly in the West Rocket Paste Area, concentrations were relatively low (less than 3 $\mu g/g$). The nitrosamines n-nitrosodi-n-propylamine (NNDNPA) and n-nitrosodimethylamine (NNDMEA) were also detected; however, these compounds were only detected at locations where NNDPA was also detected and in all but one case, sample #76 (RPS-91-38), had concentrations at least 100 times lower than the NNDPA values. Given this condition, all nitrosamine analyses are discussed in the context of the NNDPA concentrations. NNDPA distribution in the Rocket Paste Area is presented in Figure 5-4.

NNDPA concentrations in excess of 1,000 $\mu g/g$ were found in samples collected in the central portion of the East Rocket Paste Area. These locations also had elevated concentrations of several other contaminants. Nineteen of the 36 East Rocket Paste Area samples with NNDPA detects had concentrations at or below 3.92 $\mu g/g$.

In the West Rocket Paste Area, NNDPA was detected in 22 of 26 samples with concentrations ranging from 0.101 to 81 $\mu g/g$. Except for two samples (which contained NNDPA at 36 and 81 $\mu g/g$), all other sample concentrations of NNDPA were at or below 3.7 $\mu g/g$.

NG. NG was detected in the majority of samples collected from both the East and West Rocket Paste Areas. Again, the higher concentrations were detected in samples collected in the East Rocket Paste Area. NG distribution in the Rocket Paste Area is presented in Figure 5-5.

In the East Rocket Paste Area, 23 of the 38 samples had detectable concentrations of NG. Of the 23 samples with detects, 13 had concentrations less than 10 $\mu$g/g, four were between 20 and 50 $\mu$g/g; and six were between 130 and 1,500 $\mu$g/g. All samples with concentrations over 130 $\mu$g/g were again located in the central portion of the East Rocket Paste Area. Two samples had particularly high concentrations of NG (1,400 and 1,500 $\mu$g/g).

In the West Rocket Paste Area, 19 of 26 samples had detectable concentrations of NG. Of the 19 samples with detects, 14 had concentrations below 10 $\mu$g/g, while five samples were between 10 and 50 $\mu$g/g. Samples with NG levels over 10 $\mu$g/g were scattered throughout the West Rocket Paste Area.

DNT. DNT distribution in the Rocket Paste Area is presented in Figure 5-6. DNTs were not detected in any samples from the West Rocket Paste Area.

DNTs (24DNT and 26DNT) were detected in 12 of the 38 samples in the East Rocket Paste Area. 24DNT was detected at concentrations typically 5 to 15 times higher than 26DNT. 24DNT concentrations ranged from 3.15 to 810 $\mu$g/g, while 26DNT concentrations ranged from 0.783 to 32.5 $\mu$g/g. The distribution of 26DNT was similar to the distribution of 24DNT. As such, this discussion focuses on the 24DNT distribution. Two samples in the central portion of the East Rocket Paste Area had the highest DNT concentrations (560 and 810 $\mu$g/g). Four other samples also located in the central portion of the East Rocket Paste Area had concentrations between 24 and 93 $\mu$g/g. The remaining six samples with detectable DNT had concentrations less than 10 $\mu$g/g and were scattered throughout the East Rocket Paste Area. For three samples, DNT concentrations exceeded the calibration range of the instrument and values were reported as greater than 6.2 $\mu$g/g. In the two samples where detected 24DNT concentrations were the lowest (less than 3.95 $\mu$g/g), 26DNT was not detected.

PB. PB was the only metal consistently detected at concentrations above the site-specific and regional background concentrations of 10 to 30 $\mu$g/g, respectively. Although 16 samples in the East Rocket Paste Area and four samples in the West Rocket Paste Area had PB concentrations between 30 and 100 $\mu$g/g, their

distribution is sporadic at these concentrations. PB distribution in the Rocket Paste Area is shown in Figure 5-7.

In the East Rocket Paste Area, 11 of the 38 samples had PB concentrations detected at 100 to 2,200 $\mu g/g$. The highest concentration of PB (2,200 $\mu g/g$) occurred at the same sample as the highest concentration of NNDPA (RPS-91-40, #78 in Figure 5-1). The majority of other samples with PB above 100 $\mu g/g$ were also collected in the central portion of the East Rocket Paste Area. The exception to this trend occurred where PB was detected at 1,100 $\mu g/g$ in a sample taken from the north end of the East Rocket Paste Area next to the breaker and blend house facility; effluent drainage from this facility could have resulted in the high PB levels in this area.

In the West Rocket Paste Area, PB was detected in 14 of 26 samples with a concentration range of 110 to 3,500 $\mu g/g$. The highest PB concentration occurred in samples RPS-91-04 (3,500 $\mu g/g$) in the ditch which leads from the Rocket Paste Pond south through the Rocket Paste Area, and in RPS-91-18 (1,400 $\mu g/g$) in the central portion of the portion of the West Rocket Paste Area. Except for samples RPS-91-23 and 30 (580 and 730 $\mu g/g$, respectively, both located in the central portion of the West Rocket Paste Area), all other elevated PB results had concentrations between 100 and 200 $\mu g/g$.

CR and HG. CR was detected above mean background concentration of 55 $\mu g/g$ in two samples. In the Western Rocket Paste Area, one sample had CR slightly above background (66.5 $\mu g/g$). In the Eastern Rocket Paste Area, one sample had CR above background (109 $\mu g/g$). HG was detected above mean background levels (0.08 $\mu g/g$) in eight samples, with concentrations ranging from 0.083 to 0.716 $\mu g/g$. The sample with the highest CR and HG concentrations also had the highest concentration of NNDPA and PB (RPS-91-40, #78 in Figure 5-1).

TCLP Metals. In the Rocket Paste Pond/Rocket Paste Area, 68 surface soil samples were analyzed for metals leaching capacity using TCLP analysis. These tests were conducted to evaluate the leaching or migration potential for AG, BA, CD, CR, SE, HG, and PB. These analyses were conducted to determine if the surface soils at these locations would be characterized as a hazardous waste because of their high leachable metals toxicity characteristic. Only PB was detected above the Regulatory Level of 5.0 mg/L in any of the surface soil samples collected from the Rocket Paste Pond/Rocket Paste Area (Figure 5-8). One location is in the ditch south of the Rocket Paste Pond and one location is in a ditch in the West Rocket Paste Area.

Other locations in the Rocket Paste Pond and the East and West Rocket Paste areas had detectable TCLP values for PB that were below but very near the regulatory level. Other metals tested for TCLP were detected at a number of locations throughout the Rocket Paste Pond/Rocket Paste Area, but the concentrations were well below any TCLP regulatory level.

CPAH. At the West Rocket Paste Area, benzo(a)anthracene (BAANTR) was detected in one sample at a concentration of 0.193 $\mu$g/g, and chrysene (CHRY) was detected in three samples with a maximum concentration of 0.189 $\mu$g/g.

At the East Rocket Paste Area only BAANTR was detected in one sample at a concentration of 0.193 $\mu$g/g and only CHRY was detected in three samples with a maximum concentration of 0.322 $\mu$g/g. BAANTR, benzo(b)fluoranthene (BBFANT), and CHRY were all detected together in two samples, #66 (RPS-91-51) and #78 (RPS-91-40) (see Figure 5-1), with total concentrations of 3.696 $\mu$g/g and 3.275 $\mu$g/g respectively.

**Interpretations**. High concentrations of PB in surface soils were detected throughout the Rocket Paste Area drainage ditches. DNT, NG, NNDPA, and HG were also detected in the Rocket Paste Area, with the higher concentrations detected in the East Rocket Paste Area. DNT was detected only in the East Rocket Paste Area. CPAHs above the remediation goals were detected at two locations in the East Rocket Paste Area. During deactivation of the BAAP facility, the West Rocket Paste ditches were reportedly excavated. However, records of excavation in the East Rocket Paste ditches have not been identified. This is in general agreement with the higher concentrations detected in the East Rocket Paste Area.

### 5.3.2 Contamination Assessment - Surface Water

Two surface water samples were collected from both the Nitroglycerine and the Rocket Paste ponds and analyzed for Total Analyte List metals, VOCs, SVOCs, DNTs, NG, and a variety of indicator parameters. A number of metals detected in the surface water from the Rocket Paste Pond are higher than background concentrations. Table 5-2 presents a summary of the results.

In the two Nitroglycerine Pond surface water samples, AS was detected at 5.43 and 4.98 $\mu$g/L, HG was detected at 0.325 and 0.324 $\mu$g/L, and PB was detected at 41.2 and 45.9 $\mu$g/L.

In the two Rocket Paste Pond surface water samples, PB was detected at 910 and 3,100 $\mu$g/L and CR was detected at 59.5 $\mu$g/L. Surface water samples from the Nitroglycerine Pond also contained AS at concentrations of 8.6 and 15 $\mu$g/L.

### 5.3.3 Contamination Assessment - Groundwater

The groundwater contamination assessments for the NG/RPA are discussed together, primarily because of the small number of groundwater wells in the area, and the low level of contamination detected in groundwater at these locations.

Several VOCs were detected in groundwater samples from the various locations. Methylene chloride (CH2CL2) was detected in most samples, but it was also detected in the laboratory method blanks. Therefore, its presence in samples is not considered reflective of actual groundwater quality. 13DMB, diethyl ether (DEETH), TRCLE, acetone (ACET), CCL4, and MEC6H5 were all detected sporadically at low concentrations, and never in both rounds of samples from a single well. These results are not considered reflective of groundwater contamination by these compounds, as none of these VOCs were detected in concentrations or at frequencies that would indicate a significant presence in the groundwater.

SVOC analyses of groundwater samples detected B2EHP and trimethylbenzenes (TRIMBZ). B2EHP was detected in three separate wells at concentrations of 32 to 145 $\mu$g/L. However, at each well, B2EHP was only detected during one of the two sampling rounds. In addition, the spatial distribution of the detects seems random, and does not suggest actual groundwater impact. It should be noted that B2EHP is often associated with polyvinyl chloride well materials. Given these observations, the B2EHP detections are not considered reflective of actual groundwater quality. TRIMBZ was detected as a tentatively identified compound in samples from two separate wells. At both wells, the TRIMBZ detections occurred in only one round of sampling. Hence, the TRIMBZ detections are not considered reflective of actual groundwater quality.

Various metals, anions (NIT, CL and SO4), and indicator parameters were also detected in the groundwater at several locations, some above background conditions, though few above regulatory WPALs.

PB was detected above the WPAL of 1.5 $\mu$g/L at three groundwater monitoring wells. At two of these wells, PB was only detected during Round Two. However, at RPM-89-02 (see Figure 5-2), PB was detected during both rounds at

concentrations of 11.2 to 17 $\mu$g/L (above the WPAL of 1.5 $\mu$g/L). The high concentrations of PB detected in the Rocket Paste Pond and its presence in S1119 (during Round Two) suggest this result could reflect transport of PB to the water table. However, ongoing quarterly sampling of these wells, outside the USAEC Contract Laboratory Analytical Services Support (CLASS) program, by BAAP personnel have not confirmed these PB detections.

Although NO3 concentrations were detected at levels near background, NIT concentrations were detected above the WPAL of 2,000 $\mu$g/L in both sample rounds. Other parameter values appear to be uniformly distributed throughout the area, indicating a slightly degraded groundwater quality.

### 5.4 Development of Remedial Action Objectives

The baseline risk assessment for the NG/RPA presented in the Final RI Report included a human health evaluation and an environmental assessment (ABB-ES, 1993a). The baseline risk assessment determined that there is an unacceptable risk to human receptors from PB in surface soils at the Nitroglycerine Pond and from PB and NG in surface soil and sediment at the Rocket Paste Area. Subsequent to the finalization of the RI Report, numeric soil clean-up standards for AS, CD, CR, and PB based on human health risk, and numeric soil clean-up standards for C6H6, 12DCLE, ETC6H5, MEC6H5, and TXYLEN based on protection of groundwater have been presented in the proposed Chapter NR 720. For human health risk, two separate sets of clean-up standards are provided; non-industrial and industrial land use. Procedures for calculating clean-up standards for chemicals without listed numeric standards and procedures for calculating alternative clean-up standards are also included in the proposed Chapter NR 720. Applying the lowest of the human health (assuming industrial land use) and protection of groundwater standards from the proposed Chapter NR 720, for each COC, results in soil clean-up levels that are more stringent than those calculated using the criteria in the baseline risk assessment for human health. Consequently, NG/RPA soil and sediment clean-up levels for protection of human health and protection of groundwater were developed using criteria in the proposed Chapter NR 720. Soil clean-up levels for protection of ecological receptors were developed using the original risk assessment criteria contained in the Final RI Report. This subsection presents the COCs identified in the Final RI Report and summarizes the risks to human and ecological receptors. The remedial action objectives developed in this subsection, which incorporate

clean-up standards, are designed to reduce the risks posed by site contaminants to acceptable levels.

### 5.4.1 Summary of Human Health Evaluation

Surface soil (i.e., zero to 2 feet bgs), sediment (i.e., sediment in the Nitroglycerine Pond and the Rocket Paste Pond), surface water, and groundwater are the contaminated media that humans might be exposed to at the NG/RPA. The soil exposure scenario (provided in the proposed Chapter NR 720) evaluated at the NG/RPA was incidental ingestion of surface soil and inhalation of particulate matter for an adult worker. Because BAAP is currently in standby status and will be government-owned for the foreseeable future, resident exposures will not occur. Consequently, the non-industrial exposure scenario provided in the proposed Chapter NR 720 was not evaluated. In addition to evaluating the human health risks from exposure to contaminated soil, the potential for contaminants leaching from soil (surface and subsurface) and degrading groundwater quality in excess of WPALs was evaluated per the proposed Chapter NR 720.

Although scenarios associated with exposure to NG/RPA groundwater were not evaluated, groundwater quality was compared to state and/or federal groundwater standards or risk-based concentrations.

**5.4.1.1 Selection of Human Health Chemicals of Concern.** HCOCs are chemicals with inherent toxic/carcinogenic effects that are likely to pose the greatest threat to human receptors. HCOCs are present in surface soil, sediment, surface water, and groundwater at the NG/RPA. Based on the frequency of occurrence, the range of concentrations compared to background levels, and other screening criteria, the HCOCs for the NG/RPA were selected and are presented in Tables 5-3 and 5-4.

**5.4.1.2 Human Health Risk Characterization.** Surface soil and sediment risk characterizations for the Nitroglycerine Pond are discussed separately from those of the Rocket Paste Area. Because of the proximity of the two sites, the risk characterizations for groundwater at these sites have been combined and are addressed at the end of this subsection. Soil clean-up standards protective of human health that will reduce the carcinogenic and/or noncarcinogenic risk from surface soil and sediment contaminants to acceptable levels were calculated using procedures outlined in the proposed Chapter NR 720 and are presented in Table 5-5.

Nitroglycerine Pond. Potential human receptors at the site are expected to be at risk from PB in the surface soil. Because there are no dose-response values for PB, the clean-up standard for this chemical was not calculated but was obtained using the numeric standard (i.e., 500 ppm for industrial land use) listed in the proposed Chapter NR 720.

NG was detected at the Nitroglycerine Pond, but the absence of published toxicity values prevented a quantitative evaluation of risks associated with NG. A qualitative evaluation indicated that exposure to NG at the levels present at the Nitroglycerine Pond does not pose a risk to human health.

Soil and sediment clean-up standards protective of groundwater are also presented in Table 5-3. Soil and sediment contaminants which are currently a potential threat to groundwater quality are CR and PB. Leaching models were developed following the procedures outlined in the proposed Chapter NR 720, and all HCOCs were modeled to determine if the concentrations of the HCOCs in surface and subsurface soil would potentially result in exceedances of WPALs in groundwater. For organic contaminants, leaching model parameters included the partitioning between soil and water, volatilization, and degradation during migration. For metals, the only leaching model parameter was the partitioning between soil and water during migration. No modeling was attempted for anionic HCOCs (i.e., NIT and SO4) because no models exist to predict concentrations during migration of these contaminants.

Rocket Paste Area. Potential human receptors at the site are expected to be at risk from PB, 24DNT, 26DNT, BAANTR, BBFANT, CHRY, NNDPA, and NNDMEA in surface soil. In addition, risks may be associated with the concentrations of NG in surface soil although the magnitude of these risks cannot be quantified.

Because there are no dose-response values for PB, the clean-up standard for this chemical was not calculated but was obtained using the numeric standard (i.e., 500 ppm for industrial land use) listed in the proposed Chapter NR 720.

Soil and sediment clean-up standards protective of groundwater are also presented in Table 5-3. Soil and sediment contaminants which are currently a potential threat to groundwater quality are 24 DNT, 26 DNT, CR, and PB. Leaching models were developed following the procedures outlined in the proposed Chapter NR 720, and all HCOCs were modeled to determine if the concentrations of the HCOCs in surface and subsurface soil would potentially result in exceedances of WPALs in groundwater. For organic contaminants, leaching model parameters included the

partitioning between soil and water, volatilization, and degradation during migration. For metals, the only leaching model parameter was the partitioning between soil and water during migration. No modeling was attempted for anionic HCOCs (i.e., NIT and SO4) because no models exist to predict concentrations during migration of these contaminants.

Nitroglycerine Pond and Rocket Paste Area Groundwater. Contaminant concentrations in groundwater exceed groundwater standards. Table 5-6 summarizes the chemicals detected in the groundwater, the frequency of detection, and the minimum and maximum detected concentrations. The concentration of NIT exceeds the WES. Concentrations of CHCL3, CR, PB, CD, and TRCLE are below the WES but exceed WPALs. NA exceeds a reporting level for sodium-restricted diets. The monitoring wells where NIT concentrations exceeding the WES were detected are immediately downgradient of the New Acid Area, which is west of the Nitroglycerine Pond. The results indicate that releases at the New Acid facility could have impacted groundwater quality. It appears the NG/RPA are not a significant source of groundwater contamination and remedial response objectives for groundwater at these sites will not be formulated.

### 5.4.2 Summary of Baseline Ecological Assessment

Although the Nitroglycerine Pond and the Rocket Paste Pond are not permanent water bodies, the potential for aquatic biota exposure to chemicals in surface water could be realized if BAAP becomes reactivated in the future and process wastewaters are discharged to the ponds. Therefore, the potential effects of contaminated sediment and surface water on aquatic biota were addressed in the baseline ecological assessment. Exposure to aquatic and semi-aquatic receptors (including plants) was evaluated via a direct comparison between Wisconsin and federal standards and exposure point concentrations. In addition to contaminated sediment and surface water, ecological receptors could be at risk from contaminated surface soil (i.e., zero to 2 feet bgs) at the NG/RPA. Incidental soil ingestion and consumption of contaminated food are the likely exposure pathways for potential ecological receptors.

**5.4.2.1 Selection of Ecological Chemicals of Concern.** ECOCs are those chemicals having inherent toxic/carcinogenic effects that are likely to pose the greatest threat to ecological receptors. ECOCs are present in surface soil, sediment, and surface water at the NG/RPA. Based on the frequency, the range of concentrations found compared to background levels, and other screening criteria, ECOCs, for the

NG/RPA were selected. Tables 5-7 and 5-8 present the frequency and exposure point concentration for ECOCs for the Nitroglycerine Pond and Rocket Paste Area, respectively.

Only inorganic COCs were identified in surface soil, sediment, and surface water at the Nitroglycerine Pond, and in sediment and surface water at the Rocket Paste Area. Both organic and inorganic COCs were prevalent in surface soil at the Rocket Paste Area.

**5.4.2.2 Ecological Risk Characterization.** Risk characterizations for each site are discussed separately.

Nitroglycerine Pond. Aquatic and semi-aquatic receptors at the Nitroglycerine Pond are expected to be at risk from chronic exposures. The HQs associated with chronic exposure of aquatic receptors to sediment and surface water exceeded 1 for several of the COCs and ranged up to 200 for HG in sediments (Table 5-9). Aluminum (AL), HG, MN, and PB account for the risk associated with surface water, and HG and PB account for the risk associated with sediments. These results suggest that any aquatic receptors residing in this habitat could be at risk from chronic exposures to these chemicals. In addition, comparison of exposure point concentrations to Wisconsin standards for AL and HG indicates that semi-aquatic animals that forage at the pond could be impacted by these chemicals by drinking pond water or consuming contaminated food.

Sediments may contribute to the contamination of surface water as contaminants leach into the water column. No models are available that simulate contaminants leaching into the water column, but it is expected that remediation goals calculated to reduce ecological risk to acceptable levels will also reduce the leaching potential of sediments to acceptable levels.

Terrestrial receptors at the Nitroglycerine Pond are expected to be at risk from acute and chronic exposures. The HIs associated with both acute and chronic exposures exceeded 1 and ranged over several orders of magnitude (Table 5-10). These results suggest that small mammals, such as the short-tailed shrew, are at greatest risk from exposure to surface soil contaminants at the Nitroglycerine Pond (HIs for acute and chronic exposures are 19,000 and 380,000, respectively). Under both acute and chronic exposure assumptions, PB accounted for most of the risk to small mammals, small birds, and reptiles. Acute and chronic HIs estimated for these groups of receptors are sufficiently high to suggest that impacts are likely.

Rocket Paste Area. Aquatic and semi-aquatic receptors at the Rocket Paste Pond are expected to be at risk from chronic exposures. The HQs associated with chronic exposure of aquatic receptors to surface water exceeded 1 for several COCs and ranged up to 970 for PB (Table 5-11). Estimated risks associated with exposure of aquatic receptors to sediment were below 1. AL, CR, CU, iron (FE), MN, PB, and ZN account for the risks associated with surface water. These results indicate that any aquatic receptors residing in this habitat could be at risk from chronic exposure to these chemicals. In addition, comparison of exposure point concentrations to Wisconsin standards for CU indicates that semi-aquatic animals foraging at the pond could be impacted by this chemical via drinking pond water or consuming contaminated food.

Terrestrial receptors at the Rocket Paste Area are expected to be at risk for acute and chronic exposures. Acute and chronic HIs for all the indicator species were greater than 10, suggesting that most terrestrial organisms, even wide-ranging predatory species that forage at the site, could be impacted (Table 5-12). These results also suggest that small mammals, such as the short-tailed shrew, are at greatest risk from exposure to surface soil contaminants at the Rocket Paste Area (HIs for acute and chronic exposures are 6,600 and 130,000, respectively). Under both acute and chronic exposure assumptions, PB accounted for nearly all the projected risk to small mammals, small birds, and reptiles. Individual HQs for PB, 24DNT, and NG were responsible for more than 90 percent of the total acute and chronic HIs for the fox, and NNDPA (and HG for chronic exposures) were significant risk contributors to the indicator hawk species. Acute and chronic HIs estimated for these groups of receptors are sufficiently high to suggest that impacts are likely.

### 5.4.3 Identification of Remedial Action Objectives - Surface Soil

The human health risk characterization indicates that concentrations of 24DNT, 26DNT, CPAH, NNDPA, and PB in surface soil exceed clean-up standards for protection of human health developed and/or obtained from the proposed Chapter NR 720. In addition to excessive risks to human health, soil leaching models indicate that 24DNT, CR, and PB in surface soil exceed clean-up standards for protection of groundwater, also developed from the proposed Chapter NR 720. The baseline environmental assessment indicates that the ecological risks from exposure to 24DNT, 26DNT, NNDPA, PB, CR, HG, and NG by incidental surface soil ingestion and consumption of contaminated prey by terrestrial organisms exceed those considered acceptable using USEPA risk guidance. This subsection identifies the

remedial action objectives that would reduce the human health and ecological risks associated with contaminated soil to acceptable levels, and reduce the potential for further degradation of groundwater quality from surface soil contaminants leaching into groundwater.

Based on the site conditions, nature of the contaminants, migration pathways, and conclusions of the human health risk characterization and baseline environmental assessment, the following specific remedial action objectives for contaminated surface soil have been formulated:

Nitroglycerine Pond

1) Prevent concentrations of PB in surface soil which exceed clean-up standards for protection of human health (developed and/or obtained from the proposed Chapter NR 720) from becoming available, either through incidental ingestion of soil or inhalation of particulates, to potential human receptors.

2) Prevent concentrations of HG, NG, and PB in surface soil that pose an unacceptable risk from becoming available, either through incidental ingestion or consumption of contaminated prey, to potential ecological receptors.

3) Prevent concentrations of PB in surface soil which exceed clean-up standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs.

Rocket Paste Area

1) Prevent concentrations of 24DNT, 26DNT, CPAH, NNDPA, and PB in surface soil which exceed clean-up standards for protection of human health (developed and/or obtained from the proposed Chapter NR 720) from becoming available, either through incidental ingestion of soil or inhalation of particulates, to potential human receptors.

2) Prevent concentrations of 24DNT, 26DNT, NNDPA, PB, CR, HG, and NG in surface soil that pose an unacceptable risk from becoming

available, either through incidental ingestion or consumption of contaminated prey, to potential ecological receptors.

3) Prevent concentrations of 24DNT, CR, and PB in surface soil which exceed clean-up standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs.

Tables 5-13 and 5-14 list the contaminants in surface soil to be addressed during remediation, maximum detected concentrations at the NG/RPA, maximum background concentrations (for metals in surface soil), clean-up standards for the protection of human health and groundwater (developed and/or obtained from the proposed Chapter NR 720), acceptable ecological risk-based concentrations, and the recommended remediation goal with associated rationale. The maximum background concentrations are the high end of the range of either the BAAP or the regional background concentrations presented in the RI report, whichever is greatest.

Tables 5-13 and 5-14 indicate that maximum background concentrations have been selected as the remediation goals for CR, HG, and PB. Although background concentrations of these metals exceed clean-up standards for protection of human health, protection of groundwater, and/or exceed ecological risk-based values, there would be no significant benefit to potential receptors within BAAP or to the regional aquifer by remediating surface soil within small isolated areas to below background concentrations. Additionally, for some of the contaminants, the clean-up standards and/or the ecological risk-based values are below detection limits. Remediation goals set below detection limits would be unmeasurable and would probably be unattainable by most (if not all) existing soil remediation technologies.

### 5.4.4 Identification of Remedial Action Objectives - Sediment

The human health evaluation indicates that the concentration of PB in sediment at the Rocket Paste Pond exceeds the interim cleanup level of 1,000 ppm (USEPA, 1989c). The baseline ecological assessment indicates that concentrations of inorganic contaminants in sediment at the Nitroglycerine Pond present excessive risk to aquatic and semi-aquatic receptors. In addition, sediment contaminants may be contributing to surface water contamination. This subsection identifies the remedial action objectives that would reduce the risks associated with contaminated sediments to acceptable levels.

Based on site conditions, nature of the contaminants, migration pathways, and conclusions of the baseline ecological assessment, the following specific remedial action objectives for sediment have been formulated:

1) Prevent migration of contaminated sediment into drainageways downgradient of the ponds.

2) Prevent contaminants in sediment from contaminating surface water in ponds.

3) Prevent exposure of aquatic and semi-aquatic receptors to sediment at the Nitroglycerine Pond having levels of CR, HG, and PB that pose unacceptable risk.

4) Prevent human exposure to sediment at the Rocket Paste Pond that exceeds the interim cleanup level currently recommended by the USEPA (i.e., 1,000 ppm).

Tables 5-13 and 5-14 list the contaminants in sediment to be addressed during remediation, maximum detected concentrations at the NG/RPA, maximum background concentrations (for metals in surface soil), clean-up standards for the protection of human health and groundwater (developed and/or obtained from the proposed Chapter NR 720), acceptable ecological risk-based concentrations, and the recommended remediation goal with associated rationale. The maximum background concentrations are the high end of the range of either the BAAP or the regional background concentrations presented in the RI report, whichever is greatest.

Tables 5-13 and 5-14 indicate that maximum background concentrations have been selected as the remediation goals for CR, HG, and PB. Although background concentrations of these metals exceed clean-up standards for protection of groundwater and/or exceed ecological risk-based values, there would be no significant benefit to potential receptors within BAAP or to the regional aquifer by remediating surface soil within small isolated areas to below background concentrations.

### 5.4.5 Identification of Remedial Action Objectives - Surface Water

The baseline ecological assessment indicates that concentrations of inorganic contaminants in surface water at the Nitroglycerine Pond and the Rocket Paste Pond

present excessive risk to aquatic and semi-aquatic receptors. This subsection identifies the remedial action objectives that would reduce the risks associated with contaminated surface water to acceptable levels.

Based on the site conditions and the conclusions of the baseline ecological assessment, the following specific remedial action objectives for surface water have been formulated:

1) Reduce the concentrations of AL, FE, HG, MN, and PB in surface water at the Nitroglycerine Pond to levels that result in acceptable risk for aquatic and semi-aquatic receptors.

2) Reduce the concentrations of AL, CR, CU, FE, MN, PB, and ZN in surface water at the Rocket Paste Pond to levels that result in acceptable risk for aquatic and semi-aquatic receptors.

Tables 5-13 and 5-14 list the contaminants in surface water to be addressed during remediation, maximum detected concentrations, acceptable ecological risk-based concentrations, and the recommended remediation goals with associated rationale for the Nitroglycerine Pond and the Rocket Paste Pond, respectively.

## 5.5 Identification and Screening of Remedial Technologies

This subsection identifies and screens remedial technologies for surface soil, sediment, and surface water remediation at the NG/RPA. The technology identification and screening process described in Subsection 1.5 resulted in an inventory of technologies retained for the development of remedial alternatives. Development of identified remedial alternatives is presented in Subsection 5.6. Detailed evaluation of retained alternatives is presented in Section 11.

### 5.5.1 Remedial Technology Identification and Screening for Surface Soil and Sediment

This subsection identifies and screens remedial technologies for NG/RPA surface soil and sediment.

**5.5.1.1 Remedial Technology Identification - Surface Soil and Sediment.** Table 5-15 identifies general response actions and remedial technologies potentially applicable to NG/RPA surface soil and sediment.

**5.5.1.2 Remedial Technology Screening - Surface Soil and Sediment.** Technology screening is shown in Table 5-16. Technologies judged neither effective nor implementable were eliminated from further consideration. The technologies remaining after screening, summarized in Table 5-17, were subsequently used to develop remedial alternatives.

### 5.5.2 Remedial Technology Identification and Screening for Surface Water

This subsection identifies and screens remedial technologies for NG/RPA surface water.

**5.5.2.1 Remedial Technology Identification - Surface Water.** Table 5-18 identifies general response actions and remedial technologies potentially applicable to the NG/RPA surface water.

**5.5.2.2 Remedial Technology Screening - Surface Water.** Technology screening is shown in Table 5-19. Technologies judged neither effective nor implementable were eliminated from further consideration. The technologies remaining after screening, summarized in Table 5-20, were subsequently used to develop remedial alternatives.

## 5.6 DEVELOPMENT AND INITIAL SCREENING OF REMEDIAL ALTERNATIVES

In this subsection, technically feasible remedial technologies for surface soil, sediment, and surface water at the NG/RPA (retained after screening in Subsection 5.5) are assembled into remedial alternatives. The remedial alternatives are then screened on the basis of effectiveness, implementability, and cost. A description of the alternatives development and screening process is presented in Subsection 1.5.

From the technologies retained in the previous subsection, two sets of remedial alternatives are developed: surface soils and sediments, and surface water. Although the remedial response objectives differ slightly for the Rocket Paste Area media and the Nitroglycerine Pond media, one set of remedial alternatives is developed. The

relatively small quantity of surface soil in the Nitroglycerine Pond area and the relative small quantity of Rocket Paste Area sediments support such a consolidation.

### 5.6.1 Development of Remedial Alternatives - Surface Soil and Sediment

Five remedial alternatives were developed for surface soil and sediment at the NG/RPA. The alternatives, identified in Table 5-21, include a minimal action alternative, a containment alternative (Soil Cover), one excavation/treatment/disposal alternative (Excavation/Solidification/On-site Disposal), one excavation/disposal alternative (Off-site Landfill), and an in situ treatment alternative (In Situ S/S). Table 5-22 describes the key components of each alternative. A general discussion of each alternative follows.

Minimal Action. The minimal action alternative (NG/RPA-SS1) does not include containment or treatment of contaminants. This alternative would implement measures to prevent human and ecological exposure to surface soil and sediment contaminants. Fencing and signage would discourage physical access to the site for human and some ecological (e.g., deer) receptors. Institutional controls (i.e., zoning and deed restrictions) and education programs would provide added protection to human receptors. Because contaminants would remain on site, long-term management in the form of five-year site reviews is included.

Containment. One containment alternative was developed to mitigate human and ecological exposure to contaminants. The Soil Cover alternative (NG/RPA-SS2) would provide an increased level of protection to receptors as compared with that provided by the minimal action alternative. A soil cover would function as a physical barrier between contaminants and human and ecological receptors. After removal and treatment of the surface water, a soil cover would be placed over the Nitroglycerine, Overflow, and the Rocket Paste Pond sediments. Annual site inspections, groundwater monitoring, and five-year site reviews are included.

Excavation/Treatment/Disposal. One excavation/treatment/disposal alternative was developed that would achieve the remedial response objectives. Excavation/Solidification/On-site Disposal (NG/RPA-SS3), in conjunction with the backfilling of the excavation with clean fill and topsoil, would remove contaminants and associated risks from NG/RPA surface soil and sediment. This alternative maintains the integrity of the Nitroglycerine Pond. Annual site inspections, groundwater monitoring, and five-year site reviews are included at the selected disposal site. Contaminated media would be consolidated in one area.

Excavation/Off-Site Disposal. One excavation/disposal alternative was developed. Excavation/Off-site Disposal (NG/RPA-SS4) includes excavation and subsequent transportation and disposal at an off-site RCRA permitted facility. The excavation would be backfilled with clean fill.

In Situ Treatment. One in situ treatment alternative was developed. This alternative (NG/RPA-SS5) includes treatment of surface soil and sediment in situ requiring no excavation. Annual site inspections, groundwater monitoring, and five-year site reviews are included.

### 5.6.2 Development of Remedial Alternatives - Surface Water

Three remedial alternatives were developed for surface water at the NG/RPA. The alternatives, identified in Table 5-23, include a minimal action alternative and two treatment alternatives (Precipitation/Microfiltration and Ion Exchange, both followed by discharge to surface water). Table 5-24 describes the key components of each alternative. General discussion of each alternative follows.

Minimal Action. The minimal action alternative (NG/RPA-SW1) does not include containment or treatment of contaminants. This alternative would implement measures to prevent human and ecological exposure to surface water contaminants. Fencing and signage would discourage physical access to the surface water areas for human and some ecological (e.g., deer) receptors. Institutional controls (i.e., zoning and deed restrictions) and education programs would provide added protection to human receptors. Annual site inspections, surface water monitoring, and five-year site reviews are included.

Treatment/Discharge. Both treatment alternatives (NG/RPA-SW2 and -SW3) involve pumping the surface water from the Nitroglycerine, Overflow and Rocket Paste Ponds to a treatment facility. NG/RPA-SW2 would involve treatment using precipitation followed by microfiltration polishing; NG/RPA-SW3 would involve treatment using ion exchange technology. The treated surface water will be discharged downstream of the Nitroglycerine Pond.

### 5.6.3 Initial Screening of Remedial Alternatives - Surface Soil and Sediment

The five remedial alternatives for surface soil and sediment at the NG/RPA were screened for effectiveness, implementability, and cost. Components considered for each of the evaluation criteria are presented in Figure 1-5. Alternative screening is

presented in Table 5-25. Table 5-26 presents the status of each alternative based on initial screening.

### 5.6.4 Initial Screening of Remedial Alternatives - Surface Water

The three remedial alternatives for NG/RPA surface water were screened for effectiveness, implementability, and cost. Components considered for each of the evaluation criteria are presented in Figure 1-5. Alternative screening is presented in Table 5-27. Table 5-28 presents the status of each alternative based on initial screening.

## 5.7 SUMMARY OF CONTAMINATION ASSESSMENT THROUGH REMEDIAL ALTERNATIVES SCREENING

Table 5-29 was prepared to summarize the previous sections described for the Nitroglycerine Pond/Rocket Paste Area.

# 6.0 SETTLING PONDS AND SPOILS DISPOSAL AREA

## 6.1 SITE BACKGROUND AND HISTORY

The Settling Ponds and Spoils Disposal Area is located in the south-central portion of BAAP. It consists of Final Creek, four separate Settling Ponds, and five separate Spoils Disposal sites (Figure 6-1).

During approximately the first 30 years of intermittent operations at Badger, Final Creek and the Settling Ponds received sewage (which had undergone primary treatment) and neutralized industrial wastewater from most areas of the facility, and surface runoff from the Nitroglycerine, Rocket Paste, and Magazine areas. The WWTP was brought on-line in the mid-1970s. Domestic sewage and laundry waste from BAAP, except for that from the Oleum Plant and Rocket Paste areas, currently flows to the WWTP. The WWTP facility provides primary and secondary treatment of collected sanitary wastewater with a capacity of 0.5 million gallons per day (gpd). The system, capable of treating an equivalent population of 10,000 to 12,000 people, consists of an Imhoff tank, lift pumps, a high-rate trickling filter, a clarifier, and a final chlorination of the effluent. Effluent from the WWTP flows to the unlined outfall ditch (Final Creek) where it combines with general purpose sewer effluent from the drainage ditch. The Settling Ponds, with a total area of about 87 acres, served as aeration and settling basins for the treated effluent. The creek and ponds are unlined, allowing wastewater to seep into the ground. As a result, clarified wastewater rarely exits the facility into Gruber's Grove Bay, except during production periods.

According to the MEP, the Settling Ponds were first used in 1941. Settling Pond 1 was dredged and enlarged in 1970. During standby periods, Settling Pond 1 typically receives flow which fills to a surface area of approximately 0.1 acre (Fordham, 1987). All water either evaporates or infiltrates in Settling Pond 1. Settling Ponds 2 through 4 only receive overflow from Settling Pond 1, during plant mobilization (Tsai et al., 1988). The characteristics of Final Creek and the Settling Ponds are as follows (Kearny, 1987; and Ayres, 1984):

- Final Creek is approximately a mile long from the IRM facility to Settling Pond 1. Before the mid-1970s, neutralized wastewater was discharged into Settling Pond 1.

- Settling Pond 1 has an effective surface area of 24 acres; its potential volume is about 31 million gallons, based on an average depth of 4 feet.

- Settling Pond 2 receives overflow from Pond 1 as sheet flow over a dam. It is a small pond with a potential volume of about 1 million gallons.

- Settling Pond 3 is approximately 2,700 feet long with a surface area of about 25 acres. The pond receives potential overflow from Pond 2 and runoff from the central area of BAAP (including the Nitroglycerine Pond, Rocket Paste, and Magazine areas).

- Settling Pond 4 has an average depth of 3 feet, a surface area of 6 acres, and a potential volume of about 5.4 million gallons. This pond has a 20-foot semicircular weir structure with a remote monitoring station for pH and water level measurements. Settling Pond 4 discharges to Gruber's Grove Bay.

The Spoils Disposal Area, consisting of five unlined spoil sites, is adjacent to Settling Ponds 3 and 4 (see Figure 6-1). Each site was reportedly placed in a shallow depression or man-made pit. Spoils Disposal Sites 1 through 4 have been used for collecting and dewatering sludge and dredge spoil removed from the Settling Ponds. Spoils Sites 3 and 4, located south and adjacent to Settling Pond 3, contain hydraulically removed dredge spoils covered with sludge that was mechanically dredged from the Settling Ponds. Dredging activities began in late 1971 and ended in early 1973. Spoils Site 5 is a 5-acre unit initially developed in the early 1970s to receive dredged spoils and water from cleanup operations of Gruber's Grove Bay, where the Settling Ponds effluent enters the Lake Wisconsin Reservoir. The dredging of Gruber's Grove Bay, however, was not initiated. Because the bay was never dredged, Spoils Site 5 was not used for its intended purpose. It is currently lined with silty soil material approximately 1 foot deep, which reportedly was dredged from the Settling Ponds (Kearny, 1987; and Ayres, 1984).

## 6.2 Geology and Groundwater Characterization

The Settling Ponds and Spoils Disposal Area is located along the southern boundary of BAAP. The following subsections summarize the geologic and hydrogeologic

conditions at the site. The Settling Ponds and Spoils Disposal Area share similar geologic and hydrogeologic settings with the Propellant Burning Ground, which may be reflected in some of the figures, tables, or text. For a more detailed description of site conditions, refer to the Final RI Report (ABB-ES, 1993a).

### 6.2.1 Site Surface Water Hydrology

The Settling Ponds and Spoils Disposal Area consists of a series of four human-made depressions (Settling Ponds) and five dredged soil disposal sites (Spoils Disposal Area). The ponds are oriented roughly parallel and adjacent to the southern boundary of BAAP. The Settling Ponds appear to occupy a former stream channel of the Wisconsin River (Socha, 1984). The Settling Ponds and Spoils Disposal Area occupies approximately 90 to 100 acres with approximately 40 acres devoted to the Settling Ponds.

Site topography is dominated by the Johnstown terminal moraine ridge, the outwash plain west of the moraine, and the pitted surface east of the moraine. The moraine rises as much as 60 to 80 feet and is oriented northwest-southeast throughout the site. This same ridge also dominates the topography in the Propellant Burning Ground. West of the morainal ridge, the ground surface has a 5 to 10 percent downward slope to the outwash plain where slopes decrease to roughly 2 percent or less. East of the ridge, the surface relief is generally irregular. The Settling Ponds and Spoils Disposal Pits presumably are located along a stream channel and therefore have a gradual slope toward Gruber's Grove Bay and the Lake Wisconsin Reservoir.

Surface water runoff at the Settling Ponds and Spoils Disposal Area primarily consists of ephemeral flows of spring runoff following snowmelt. The morainal ridge forms a surface water divide forcing a portion of runoff to flow westward toward the outwash plain (where it may drain into Final Creek), and the remainder to flow eastward into poorly defined drainage patterns. Most surface runoff that does occur in the east is captured in isolated depressions and then evaporates or infiltrates.

Surface water collected in Final Creek is routed and deposited into the Settling Ponds, barring any evaporation or infiltration. Surface water from other sites (e.g., Nitroglycerine Pond, Rocket Paste Area, and Deterrent Burning Ground) could eventually flow to the Settling Ponds via the existing series of unlined drainage ditches. Surface water is collected in the ponds and, if not evaporated or infiltrated, eventually flows through Pond 4 and out to Gruber's Grove Bay. The river only

receives runoff through the Settling Ponds during extreme snowmelt or rain events. One such event occurred during a thaw in January 1989. During this event, water was observed flowing from the Settling Ponds to the Lake Wisconsin Reservoir.

### 6.2.2 Site Geology

Soil borings and monitoring wells installed at the Settling Ponds and Spoils Disposal Pits encountered soil conditions consistent with those observed at other BAAP locations. These conditions include approximately 250 feet of unconsolidated soil deposited in association with the maximum advance of the Green Bay Lobe Glacier (Alden, 1918; and Thwaites, 1958).

Geologic cross-sections depicting generalized stratigraphic relationships among the various soil units at the site are oriented in Figure 6-2 and shown in Figure 6-3. Generally, the stratigraphic sequence includes a 5- to 10-foot-thick veneer of loess immediately below the ground surface underlain by variably textured sands and gravels with occasional cobble and boulder zones. No substantial silty or clayey tills were encountered within the sand and gravel zone in the borings installed during 1989. However, borings installed by Warzyn in 1982 encountered a silty and clayey till unit in the northeastern portion of the Settling Ponds and Spoils Disposal Area (Warzyn, 1982a).

At an approximate elevation of 700 to 725 feet MSL, a continuous 10-to-20-foot-thick cobble and gravel layer (oriented north-south) was encountered. This coarse layer appears to be west of and parallel to the axis of the terminal moraine. This coarse-grained unit is laterally extensive along the western boundary of the terminal moraine at BAAP and could extend to the Baraboo Hills north of BAAP parallel to the terminal moraine. Boring logs from wells in the region suggest this unit may extend south of BAAP to the Town of Prairie du Sac.

Underlying the cobble and gravel layer are additional deposits of variably textured sands and gravel. Immediately above bedrock another gravel cobble layer was encountered. Finally, sandstone bedrock belonging to the Eau Claire Formation was encountered at an approximate elevation of 600 to 620 feet above MSL. This bedrock appears to have a relatively flat surface with a gentle slope to the southeast.

### 6.2.3 Site Hydrogeology

Hydrogeologic conditions at the Settling Ponds and Spoils Disposal Area are controlled mainly by geologic conditions underlying the area. In addition, the area is influenced by the elevated water level in the Lake Wisconsin Reservoir and the lower water level below the WP&L dam.

The near-surface, fine-grained loess unit restricts the infiltration of precipitation to approximately 5 to 9 inches per year. Below the loess, the thick layer of sand and gravel comprises a considerable vadose zone through which groundwater must percolate before recharging the water table. The water table occurs in coarse-grained sands and gravels, which results in relatively small vertical gradients and uniform horizontal gradients across the water table. Vertical gradients could reflect flow into the gravel/cobble layer from above and below.

Generally, groundwater flows south, with a southwesterly flow component in the southeastern portion of the Settling Ponds and Spoils Disposal Area. The transition of groundwater flow from south-to-southwest apparently reflects the influence of the elevated water level in the Lake Wisconsin Reservoir east of BAAP. The WP&L dam, approximately 1.5 miles south of the BAAP boundary, has an approximate 40-foot head difference across the dam. The elevated water level in the reservoir (approximately 774 feet MSL) forms a gradient that could allow for discharge to groundwater from the Lake Wisconsin Reservoir in this area.

Hydraulic conductivity tests (in situ rising-head tests) were completed by ABB-ES in 29 wells at the nearby Propellant Burning Ground. The tests focused on the shallow and deep monitoring wells, and indicate a hydraulic conductivity range of $1x10^{-3}$ to $2x10^{-1}$ cm/sec, with a median value of $4x10^{-2}$ cm/sec. Horizontal gradients at the Settling Ponds and Spoils Disposal Area are also similar to those calculated for the Propellant Burning Ground, ranging from approximately 0.0012 to 0.0015 ft/ft.

Groundwater flow velocity analyses were performed for conditions in the area (both the Propellant Burning Ground and the Settling Ponds) and indicate a velocity range of 30 to 460 ft/yr. The median velocity is roughly 330 ft/yr. The higher velocities are most likely associated with the coarse gravel/cobble zone while the lower velocities reflect conditions in finer, sandier zones. The velocity analyses assume that areas with higher transmissivities generally have a somewhat lower hydraulic gradient. This condition occurs naturally because the higher the transmissivity the

lower the resistance to flow and the lower the hydraulic gradient that can be supported.

### 6.3 CONTAMINATION ASSESSMENT

The soil and groundwater contamination assessment summary is based on data presented in the Final RI Report (ABB-ES, 1993a).

#### 6.3.1 Contamination Assessment - Surface Soil

Surface soil and sediment samples from the Settling Ponds and Spoils Disposal Area were collected in four previous sampling programs by contractors other than ABB-ES. A summary of the results is presented here. Figure 6-4 shows the sample locations and Figure 6-5 shows the distribution of surface soil contaminants.

Final Creek. The result of the chemical analysis from the nine surface soil/sediment samples revealed concentrations elevated above background for selected inorganic and organic parameters. PB, NH3, and SO4 were detected at concentrations above background concentrations. PB was detected in one of the nine samples at a concentration of 40 $\mu$g/g, which is above the 30 $\mu$g/g background sediment concentration. NH3 was detected at concentrations above the 320 $\mu$g/g maximum background concentration in only one of the eight samples submitted for NH3 analyses. SO4 was detected in five of the nine samples submitted for SO4, ranging from 18.2 to 260 $\mu$g/g. SO4 was not detected in background samples. Tin (SN) was detected in seven of eight samples, with a maximum concentration of 63 $\mu$g/g. All seven samples contained concentrations of SN exceeding the maximum eastern United States background soil concentration of 10 $\mu$g/g (USGS, 1984).

24DNT and 26DNT were detected in six of the nine samples, at maximum concentrations of 6 $\mu$g/g and 40 $\mu$g/g, respectively. 2NNDPA was detected in three samples with a maximum concentration of 2 $\mu$g/g. DPA was detected in six of the nine samples, with a maximum concentration of 15 $\mu$g/g. The surface soil/sediment sample from SPB-91-01 also contained low concentrations of a variety of SVOCs including acenaphthylene (ANAPYL), benzo(a)anthracene (BAANTR), BBFANT, benzo(k)fluoranthene (BKFANT), benzo(g,h,i)perylene (BGHIPY), CHRY, PHANTR, and PYR. The total concentration of these SVOCs was 3.658 $\mu$g/g and the highest concentration for a single compound was 0.723 $\mu$g/g. Results of

extraction procedure (EP) toxicity leaching tests indicated concentrations did not exceed RCRA EP toxicity test criteria.

Settling Pond 1. Surface soil/sediment samples from Pond 1 were fine-grained cohesive soils. Granular soils were encountered in the lower portion of some of the Shelby tube samples (Ayres Assoc., 1984). The sediments in Pond 1 were found to have a thickness of zero to 5 feet (Envirodyne Engineering, 1981). Eighteen surface soil/sediment samples were submitted for chemical analyses. Results of the analyses are summarized in Table 6-15 of the Final RI Report (ABB-ES, 1993a). The principal inorganic analytes detected above background concentrations are PB, SN, and SO4. PB was detected in four of 18 sediment samples at concentrations between 30 $\mu$g/g (maximum background sediment concentration) and 100 $\mu$g/g. Three other samples had PB concentrations between 100 and 180 $\mu$g/g. SN was detected in 17 of the 17 samples and at concentrations above the maximum regional background concentration of 10 $\mu$g/g in 14 of 17 samples. SO4 was detected in eight of the 18 samples, with five of these samples having concentrations over 100 $\mu$g/g. SO4 was not detected in background samples.

Organic analyses detected 24DNT and/or 26DNT in seven of 18 samples, with maximum concentrations of 172 $\mu$g/g and 40 $\mu$g/g, respectively. 2NNDPA was detected in three of the 18 samples. DEP was detected in only one of the 18 samples. DPA was detected in six of the 18 samples. NC was detected in seven of the 18 samples.

Results of EP toxicity tests on 14 of the samples from Pond 1 were below the RCRA EP toxicity test criteria.

Settling Pond 2. The sediments encountered in Pond 2 were typically described as silts with more granular sandy soils being encountered at depth. The results of chemical analyses on the four sediment/surface soil samples collected from Pond 2 are summarized in Table 6-15 of the Final RI Report (ABB-ES, 1993a). The principal inorganic analytes detected above background concentrations in these samples from Pond 2 are PB and SN. PB was detected in all samples above the background concentration. SN concentrations exceed the maximum regional background concentration in all samples.

24DNT, DEP, and DPA were each detected in one sample. NC was detected in two samples.

Results of EP toxicity tests on three of the samples from Pond 2 were below the RCRA EP toxicity test criteria.

Settling Pond 3. Fine-grained silty soils grading to coarser sandy soils at depths to 5 feet were encountered in the samples from Pond 3. The principal inorganic analytes exceeding background concentrations are PB, NH3, and SN. PB was detected in all 15 samples, although only two of the results exceeded the PB background concentration. NH3 was also detected in all 15 samples analyzed for NH3, although only two of the samples exceeded the background concentration.

The SVOCs detected include: 24DNT in one sample; 26DNT in one sample; DEP in one sample; DPA in four samples; and NC in two samples.

Results of EP toxicity tests on 15 of the samples from Pond 3 did not exceed RCRA EP toxicity test criteria.

Settling Pond 4. The surficial soils encountered in Pond 4 were largely silts and clays with poorly graded sands in some areas. The principal inorganic analytes exceeding background concentrations are PB, NH3, SO4, SN, and AL. PB concentrations exceeded background levels in all 11 samples. NH3 concentrations were above background concentrations in six samples. Of the 11 samples analyzed for SO4, only three had detectable concentrations. SN exceeded the maximum regional background concentration in 10 of the 11 samples analyzed. AL was detected in all 11 samples, but only one sample contained a concentration greater than background.

DPA was detected in one sample and NC was detected in two samples.

Results of EP toxicity tests conducted on 10 sediment/surface soil samples from Pond 4 did not exceed RCRA EP toxicity test criteria.

Spoil Disposal Site 1. Five surface soil samples were collected from Spoil Site 1. The principal inorganic compounds detected at Spoil Site 1 were PB, ZN, and SO4. PB concentrations exceeded background in all five samples. ZN was detected in four of five samples at concentrations above the site background concentration. SO4 was detected in all five samples.

Organic analyses were conducted on the five samples from Spoil Site 1. Three samples were analyzed for 24DNT and all three were reported to contain the

compound. DPA was detected in four of the five samples. NC was detected in all five samples. NG was detected in one of one sample.

Spoil Disposal Site 2. Five surface soil samples were collected from Spoil Site 2. The principal inorganic analytes detected above background concentrations in all five samples were again PB, ZN, and SO4.

Organic analyses detected NC and DPA in all five samples.

Spoil Disposal Site 3. Ten surface soil samples were collected from Spoil Site 3. The principal inorganic analytes detected above background concentrations were PB and ZN. PB was detected in nine of 10 samples at concentrations above the regional background concentration. ZN was detected in all 10 samples at concentrations above the site background concentration.

di-n-octyl phthalate (DNOP) was detected in one of the 10 samples. DPA was detected in four of the 10 samples. NC was detected in all 10 samples.

Spoil Disposal Site 4. Ten surface soil samples were collected from Spoil Site 4. The principal inorganic analytes detected above background concentrations were PB and ZN. PB was detected in five of 10 samples at concentrations above the regional background concentration. ZN was detected in all 10 samples at concentrations above the site background concentration.

DNOP was detected in three of the 10 samples; DPA was detected in one of the 10 samples; NC was detected in nine of the 10 samples.

Spoil Disposal Site 5. Ten surface soil samples were collected from Spoil Site 5. The principal inorganic analytes detected above background concentrations were PB and ZN. PB was detected in five of 10 samples at concentrations above the regional background concentration. ZN was detected in nine of 10 samples at concentrations above the site background concentration.

DNOP was detected in one of the 10 samples; DPA was detected in three of the 10 samples; NC was detected in eight of the ten samples.

### 6.3.2 Contamination Assessment - Subsurface Soil

Boring SPB-91-01 was drilled under the direction of ABB-ES at Final Creek south of the WWTP (see Figure 6-4). Subsurface soil sampling in the Settling Ponds and Spoils Disposal Area was performed by Envirodyne Engineers, Inc. (Envirodyne Engineers, Inc, 1981). Seven borings, S1201 through S1207, were drilled in 1980 to assess potential surface and subsurface contamination in Settling Ponds 1 through 4. Samples from these borings were composited over depths of zero to 15 feet and 15 to 30 feet bgs. Because the samples were composites, actual distributions and concentrations of compounds with depth is unknown. The reported distribution of contaminants in composited samples collected in these borings is discussed, and used for the purposes of developing remedial alternatives.

In general, concentrations of subsurface contaminants decreased downstream from Final Creek to Settling Pond 4, and with increased depth below ground surface. No analytes detected in subsurface soils have been detected in groundwater at concentrations above background at the Settling Ponds and Spoils Disposal Area; therefore, subsurface soils in this area are not considered a source for contaminants detected in groundwater at Final Creek. Contaminants detected in groundwater at Final Creek are believed to be a result of the source contamination at the Propellant Burning Ground located upgradient.

SVOCs detected in the Final Creek boring SPB-91-01, at a depth of 2 feet, are low in concentration and have not typically been detected in soil samples at BAAP. HG, detected in the 2-foot sample of SPB-91-01, is known to have been used historically in various agricultural fungicides and pesticides. However, no documentation of the use of these compounds at BAAP has been identified. TL was also detected in samples from SPB-91-01. Concentrations of TL were not commonly detected in other soil samples at BAAP.

Subsurface soils collected from the Settling Ponds were analyzed for a limited set of analytes. 24DNT, DNBP, DEP, NC, and PB detected in the samples are attributable to processes undertaken during production periods at BAAP. Verified migration of these contaminants in subsurface soils at the Settling Ponds appears limited; definition of the depth of these contaminants is difficult to interpret because of the composite sampling intervals.

Final Creek. The primary contaminants detected in the six subsurface soil samples from SPB-91-01 were SVOCs, HG, and TL in the 2-foot sample. The SVOCs in the

samples were in low concentrations, totaling 3.658 $\mu g/g$. C6H6 and MEK were reported in low concentrations in the 67-foot sample; however, both were dismissed as laboratory contaminants (ABB-ES, 1993a).

The metals TL and HG were detected at concentrations exceeding background. TL was detected from ground surface to a depth of 22 feet bgs. HG was detected in the 2-foot sample. Other metals and anions in SPB-91-01 samples were within background ranges for surface and subsurface soils.

Settling Pond 1. The primary contaminants detected in subsurface soils in borings S1201 through S1204 were 24DNT, DEP, and DBP. DEP and 24DNT were generally detected at low concentrations, except at S1223 and S1203, were elevated concentrations were detected at a reported depth of 3 feet bgs (apparently composited between 3 feet and 15 feet bgs). Low concentrations of these compounds were detected in composited samples collected below 15 feet bgs in these two borings. DBP was detected at relatively low concentrations (less than 3.0 $\mu g/g$) in each composited sample.

Settling Ponds 2, 3, and 4. Borings S1205, S1206, and S1207 were drilled in Settling Ponds 2, 3, and 4, respectively. In general, concentrations of the detected chemicals decrease downstream from Ponds 2 to 4, towards Gruber's Grove Bay. The primary contaminants detected in subsurface soils in these borings were 24DNT, DEP, and DBP, and each was detected at low concentrations.

### 6.3.3 Contamination Assessment - Groundwater

The contamination found in groundwater at the Settling Ponds and Spoils Disposal Area appears to be characteristic of the Propellant Burning Ground plume, and inconsistent with contaminants detected at the Settling Ponds and Spoils Disposal Area. VOCs (CCL4 and TRCLE) were detected in wells S1133, SPN-89-01C, SPN-89-02B and C, SPN-91-02D, SPN-89-03B and C, SPN-91-03D, SPN-89-04B and C, and S1103 in both Round One and Round Two. CCL4 and TRCLE plumes and sample locations are described with the Propellent Burning Ground groundwater assessment. For a more detailed assessment of Propellant Burning Ground groundwater contamination, see Subsection 3.3.3 of this report and also Subsection 6.4.2.5 of the Final RI Report (ABB-ES, 1993a).

### 6.4 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

The baseline risk assessment for the Settling Ponds and Spoils Disposal Area presented in the Final RI Report included an environmental assessment and a human health evaluation (ABB-ES, 1993). Subsequent to the finalization of the RI Report, numeric soil clean-up standards based on human health risk and numeric soil clean-up standards based on protection of groundwater have been presented in the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code. For human health risk, two separate sets of clean-up standards are provided; non-industrial and industrial land use. Procedures for calculating clean-up standards for chemicals without listed numeric standards and procedures for calculating alternative clean-up standards are also included in the proposed Chapter NR 720. Applying the lowest of the human health (assuming industrial land use) and protection of groundwater standards from the proposed Chapter NR 720, for each COC, results in soil clean-up levels that are more stringent than those calculated using the criteria used in the baseline risk assessment for human health. Consequently, soil clean-up levels for protection of human health and protection of groundwater were developed using criteria in the proposed Chapter NR 720. Soil clean-up levels for protection of ecological receptors were developed using the original risk assessment criteria contained in the Final RI Report. This subsection presents the COCs identified in the Final RI Report and summarizes the risks to human and ecological receptors. The remedial action objectives developed in this subsection, which incorporate clean-up standards, are designed to reduce the risks posed by site contaminants to acceptable levels.

Surface soil (i.e., zero to 2 feet bgs), subsurface soil (i.e., zero to 15 feet bgs), and groundwater are the contaminated media that humans might be exposed to at Final Creek, the Settling Ponds and the Spoils Disposal Area. The soil exposure scenario (provided in the proposed Chapter NR 720) evaluated was incidental ingestion of soil (surface and subsurface) and inhalation of particulate matter for an adult worker. Because BAAP is currently in standby status and will be government-owned for the foreseeable future, resident exposures will not occur. Consequently, the non-industrial exposure scenario provided in the proposed Chapter NR 720 was not evaluated. In addition to evaluating the human health risks from exposure to contaminated soil, the potential for contaminants leaching from soil (surface and subsurface) and degrading groundwater quality in excess of WPALs was evaluated per the proposed Chapter NR 720.

Although scenarios associated with exposure to groundwater at the Settling Ponds were not evaluated, groundwater quality was compared to state and/or federal groundwater standards or risk-based concentrations.

### 6.4.1 Selection of Human Health Chemicals of Concern

HCOCs are chemicals with inherent toxic/carcinogenic effects that are likely to pose the greatest threat to human receptors. HCOCs are present in surface and subsurface soils at Final Creek, the Settling Ponds, and Spoils Disposal Area. Based on the frequency of occurrence, the range of concentrations compared to background levels, and other screening criteria, the HCOCs in soil were selected and are presented in Table 6-1 with their exposure point concentrations.

### 6.4.2 Human Health Risk Characterization

Soil clean-up standards protective of human health, calculated using procedures outlined in the proposed Chapter NR 720, that will reduce the carcinogenic and/or noncarcinogenic risk from surface and subsurface soil contaminants at Final Creek and the Settling Ponds and at the Spoils Disposal Area to acceptable levels are presented in Tables 6-2 and 6-3, respectively. Based on a comparison of exposure point concentrations in Table 6-1 with results in Table 6-2, potential human receptors at Final Creek and the Settling Ponds are expected to be at risk from 24DNT, 26DNT, and CPAH (predominantly at the Final Creek outflow) in surface soil and 24DNT in subsurface soil. Similarly, potential human receptors at the Spoils Disposal Sites are expected to be at risk from 24DNT in surface soil.

Soil clean-up standards protective of groundwater are also presented in Tables 6-2 and 6-3. Surface and subsurface soil contaminants which are currently a potential threat to groundwater quality are 24DNT and PB at Final Creek and the Settling Ponds and 24DNT, PB and ZN at the Spoils Disposal Area. Leaching models were developed following the procedures outlined in the proposed Chapter NR 720 and all HCOCs were modeled to determine if the concentrations of the HCOCs in surface and subsurface soil would potentially result in exceedances of WPALs in groundwater. For organic contaminants, leaching model parameters included the partitioning between soil and water, volatilization, and degradation during migration. For metals, the only leaching model parameter was the partitioning between soil and water during migration. No modeling was attempted for anionic HCOCs (i.e., NIT and SO4) because no models exist to predict concentrations during migration of these contaminants.

### 6.4.3 Summary of Baseline Ecological Assessment

BAAP is on standby status and wastewater production is relatively low. For the most part, effluent infiltrates or evaporates in Settling Pond 1, allowing the other three ponds to remain relatively dry. Wetlands vegetation is present in the Settling Ponds, but, because of a lack of standing water, no aquatic macroinvertebrates and/or fish are present within the ponds. As a result, only terrestrial organisms will likely be exposed to contamination in the area. Surface soil (i.e., zero to 2 feet bgs) is the only medium to which terrestrial organisms may be exposed and incidental soil ingestion and consumption of contaminated food are the likely exposure pathways for these potential receptors.

**6.4.3.1 Selected Ecological Chemicals of Concern.** ECOCs are chemicals with inherent toxic/carcinogenic effects that are likely to pose the greatest threat to ecological receptors. Based on the frequency of occurrence, the range of concentrations found compared to background levels, and other screening criteria, the ECOCs were selected and are presented in Table 6-4.

**6.4.3.2 Ecological Risk Characterization.** Based on the results summarized in Table 6-5, ecological receptors at the Settling Ponds, Spoils Disposal Areas, and the Final Creek Area are expected to be at risk from both acute and chronic exposures. Small mammals such as the short-tailed shrew appear to be at greatest risk from exposure to surface soil constituents. Estimated acute and chronic HIs for this indicator species ranged over several orders of magnitude, but at all 10 areas, impacts are predicted to be likely for this type of receptor. PB was consistently found to be the surface soil constituent that accounted for most of the overall HI score. The other compounds of concern found to be significant risk contributors include SN and AL (Settling Pond 4). The acute and chronic HIs estimated for this group of receptors are sufficiently high to suggest that impacts are likely. In all cases, the chronic HIs were of greater magnitude, and as a result, the most likely type of impacts expected in the overall area would be adverse effects on small mammal reproduction. However, acute lethal effects are also anticipated based on the findings that predicted exposure concentrations are up to three orders of magnitude greater than those required to cause mortality in laboratory populations.

HIs for the other modeled indicator species are lower than those estimated for small mammals. However, small birds and reptiles that regularly forage in the vicinity of the Settling Ponds and Spoils Disposal Area would also likely be impacted. As was

the case with rodents, PB and SN were the soil constituents most responsible for projected risk.

PB appears to be an ubiquitous surface soil contaminant in these sites, being detected in nearly all analyzed samples. The toxicological literature available for PB is fairly extensive and there is ample evidence to suggest that PB dosages (normalized to body weight) on the order of 0.1 to 5 mg/kg-day are sufficient to cause adverse effects in a variety of ecological receptors. PB exposure concentrations for small rodents, considering both direct soil ingestion and indirect exposure to surface soil constituents via food-chain transfer, were typically in the range of 500 - 10,000 mg/kg-day.

SN is estimated to be a significant risk contributor for secondary consumer indicator species (e.g., fox and hawk) at Final Creek and the Settling Ponds sites, and this inorganic constituent was also regularly detected in surface soils associated with these sites. Although the toxicological benchmark levels for SN are of the same magnitude as PB, estimated exposure concentrations for primary consumer indicator species (i.e., rodents and small birds) are somewhat lower because SN concentrations were not as elevated as PB. However, food chain transfer of SN is expected to be of greater magnitude than for PB, given the higher bioaccumulation factors for uptake by prey items of these top predatory species.

The detected AL concentrations are responsible for a significant proportion of the overall estimated risk found at Settling Pond 4, accounting for 80 percent of the acute HIs for the fox and hawk, and approximately 63 percent of the chronic HI for small birds.

At the Spoils Disposal Area sites, ZN and PB typically accounted for more than 90 percent of the HI scores; for the top predator indicator species, ZN was often the largest risk contributor. The shift in the relative importance of ZN and PB between primary and secondary species is due to differences in bioaccumulation factors for these two inorganics.

### 6.4.4 Identification of Remedial Action Objectives - Soil

The human health risk characterization indicates that concentrations of 24DNT, 26DNT, and CPAH in surface soil and 24DNT in subsurface soil exceed clean-up standards for protection of human health developed from the proposed Chapter NR 720. In addition to excessive risks to human health, soil leaching models indicate that 24DNT, PB, and ZN in soil exceed clean-up standards for protection of groundwater, also developed from the proposed Chapter NR 720. The baseline ecological assessment indicates that the ecological risks associated with incidental soil ingestion and consumption of contaminated prey by terrestrial organisms are unacceptable due to elevated PB, SN, ZN, AL, DEP, DPA, and NG concentrations. This subsection identifies the remedial action objectives that would reduce the human health and ecological risks associated with contaminated soil to acceptable levels, and reduce the potential for further degradation of groundwater quality from surface soil contaminants leaching into groundwater.

Based on site conditions, nature of the contaminants, migration pathways, and conclusions of the baseline ecological assessment and the human health evaluations, the following specific remedial action objectives for contaminated surface soil have been formulated:

1) Prevent migration of contaminated soil by soil erosion.

2) Prevent the exposure of terrestrial receptors to surface soil at Final Creek and the Settling Ponds containing concentrations of PB (excluding Settling Pond 3) and SN that pose unacceptable risk.

3) Prevent the exposure to terrestrial receptors to surface soil containing concentrations of DEP (at Settling Ponds 1, 2, and 3) and DPA (at Final Creek and Settling Pond 1) that pose unacceptable risk.

4) Prevent the exposure of terrestrial receptors to surface soil at Settling Pond 4 containing concentrations of AL that pose unacceptable risk.

5) Prevent the exposure of terrestrial receptors to surface soil at the Spoils Disposal Sites containing concentrations of ZN and PB that pose unacceptable risk.

6) Prevent the exposure of terrestrial receptors to surface soil at Spoils Disposal Site 1 containing concentrations of DPA and NG that pose unacceptable risk.

7) Prevent the exposure of human receptors to soil at Final Creek and the Settling Ponds containing concentrations of 24DNT, 26DNT, and CPAH that pose unacceptable risk.

8) Prevent the exposure of human receptors to soil at the Spoils Disposal Sites containing concentrations of 24DNT that pose unacceptable risks.

9) Prevent concentrations of 24DNT and PB in soil at Final Creek and the Settling Ponds which exceed cleanup standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs.

10) Prevent concentrations of 24DNT, PB, and ZN in soil at the Spoils Disposal Sites which exceed cleanup standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs.

Tables 6-6 and 6-7 present the soil contaminants to be addressed during remediation, detection limits, maximum detected concentrations, maximum background concentrations, protection of groundwater soil target concentrations and protection of human health concentrations (developed from proposed Chapter NR 720), protection of ecological receptors concentrations, and recommended remediation goal and rationale for Final Creek and Settling Ponds and the Spoils Disposal Areas, respectively. The maximum background concentrations are the high end of the range of either the BAAP or regional background concentrations, whichever is greatest.

Table 6-6 and 6-7 indicate that the maximum background concentrations have been selected as the remediation goal for AL, PB, SN, and ZN which will result in acceptable risk for terrestrial organisms. Although background concentrations exceed the risk-based values for AL, PB, SN, and ZN by as much as three orders of magnitude, there could be no significant benefit to the populations of terrestrial organisms within BAAP by remediating small isolated areas to below background levels. Additionally, the risk-based values are below detection limits and would, therefore, be unattainable by soil remediation.

### 6.4.5 Identification of Remedial Action Objectives - Groundwater

There are no ecological risks associated with contaminated groundwater. Human health risks associated with groundwater at the Settling Ponds and Spoils Disposal Area are due to the contaminant plume at the Propellant Burning Ground. Remedial action objectives are addressed with those for the Propellant Burning Ground earlier in this report.

## 6.5 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

This subsection identifies and screens applicable technologies for soil at the Settling Ponds and Spoils Disposal Sites. The result of the screening is a list of applicable technologies retained for the development of remedial alternatives, which is presented in Subsection 6.6.

Treatment technologies were identified based on a review of the Remedial Technology Handbook developed for BAAP, review of other available technology literature, vendor information, and previous feasibility and design experience. Because the Remedial Technology Handbook was developed specifically for contaminants at BAAP, it was used as the primary source for technology identification.

Site characteristics included:

- site geology, hydrogeology, and topography;
- space and resource restrictions associated with implementation of a technology; and
- the presence of any special site features or restrictions (e.g., pavement, buildings, underground utilities)

The identification process considered both the specific site and waste characteristics. Waste characteristics considered included:

- type of contaminants;
- contaminant concentrations; and

- physical and chemical properties of the contaminants (e.g., volatility, solubility, and mobility).

In the screening process, the number of identified technologies was reduced by evaluating the advantages and disadvantages of each technology with respect to the technology's effectiveness and implementability. The technologies retained for alternative identification were those that have the potential to effectively remediate the site, either alone or with other technologies. This process for technology screening is consistent with the USEPA RI/FS Guidance document (USEPA, 1988b).

### 6.5.1 Remedial Technology Identification and Screening for Soil

This subsection identifies and screens remedial technologies for soil at the Final Creek, the Settling Ponds and the Spoils Disposal Area using the criteria discussed above.

**6.5.1.1 Remedial Technology Identification - Soil.** Remedial technologies applicable to the Settling Ponds and Spoils Disposal Area are identified in Table 6-8. The table also identifies the general response action associated with the technology followed by a brief description.

**6.5.1.2 Remedial Technology Screening - Soil.** The screening of the technologies is shown in Table 6-9. Those technologies considered not effective or implementable were eliminated from further consideration. Table 6-10 lists those technologies retained and subsequently used to develop remedial alternatives.

## 6.6 Development and Initial Screening of Remedial Alternatives

In this subsection, technically feasible technologies for soil are assembled into remedial alternatives, which are further screened based on their effectiveness, implementability, and cost. A description of the alternatives development and screening process is presented in Subsection 1.7.

### 6.6.1 Remedial Alternatives Development for Soil

This subsection presents the remedial alternatives for soil at Final Creek, the Settling Ponds, and the Spoils Disposal Area.

**6.6.1.1 Development of Remedial Alternatives - Soil.** Eight remedial alternatives were developed for the treatment of soils at final Creek, the Settling Ponds and the Spoils Disposal Area. These alternatives include one minimal action alternative, two containment alternatives, one excavation/disposal alternative, and four treatment alternatives. Table 6-11 identifies these alternatives and the technologies that make up their components. Table 6-12 provides descriptions of the key components in each alternative; a general discussion is provided in the following paragraphs.

Minimal Action. The minimal action alternative, SSP-SS1, does not provide containment or treatment of contaminants. However, this alternative serves as a baseline to the other alternatives and assesses the impacts on human health and the environment if no action were taken. Institutional controls such as zoning and deed restrictions as well as education programs would provide added protection for human health. Because the contaminants remain on site, this alternative would include five-year site reviews to monitor the effectiveness of minimal action.

Containment. The first containment alternative, SSP-SS2 Soil Cover, was developed to reduce the potential mobility of contaminants and to reduce human and ecological exposure to contaminants. A soil cover would provide an increased level of protection for human and ecological receptors beyond that of the minimal action alternative. The soil cover would prevent direct contact of the contaminants, prevent contaminant migration off site via soil erosion, and potentially reduce contaminant migration by directing surface runoff away from contaminated areas and ultimately reducing contaminant migration by reducing infiltration. This reduction in infiltration could be enhanced by selecting a grading and cover fill exhibiting a relatively low hydraulic conductivity. The Five-year reviews are included with this alternative.

The second containment alternative, SSP-SS3 Capping, was developed to reduce the mobility of contaminants and to reduce human and ecological exposure to contaminants. The cap would provide an increased level of protection for human and ecological receptors beyond that of the minimal action alternative and soil cover alternative. A RCRA cap would prevent direct contact of the contaminants, prevent contaminant migration off site via soil erosion, and significantly reduce contaminant migration by mitigating contaminant migration that could occur via water infiltration. Five-year reviews are included with this alternative.

Excavation/Disposal. The excavation/disposal alternative, SSP-SS4, reduces receptor exposure to contaminated soil. This alternative would remove the contaminants and

their associated risks from the site for disposal in an off-site, RCRA-licensed landfill. The excavations would be backfilled with clean fill.

Treatment. The four alternatives listed under this heading are as follows:

- SSP-SS5, Soil Washing. This alternative would result in the reduction of contaminants on site. The contaminants would be concentrated to a fraction of their original volume and transported off site. The soil remaining on site would be used as backfill for the excavations.

- SSP-SS6, Ex Situ Stabilization/Solidification and Soil Cover. This alternative provides a higher level of protection than the minimal action and soil cover. The contaminants would be physically/chemically immobilized, eliminating the potential for ecological receptor contact. The soil would be treated, though the toxicity and volume of contaminants remaining on site would stay the same. Five-year site reviews would be included.

- SSP-SS7, Modified In Situ Stabilization/Solidification and Soil Cover. Similar to SSP-SS6, except that contaminated surface soil is solidified in-place. Contaminated subsurface soil would be excavated, stockpiled and solidified within the limits of the Settling Ponds. Five-year site reviews would be included.

- SSP-SS8, Stabilization/Solidification and Off-Site Landfill. In this alternative, the contaminants would be physically/chemically immobilized by ex situ techniques, then disposed of off site. The result is an elimination of on-site contaminants exceeding remediation goals. Backfill with clean fill would be included.

**6.6.1.2 Initial Screening of Remedial Alternatives - Soil.** The eight remedial alternatives were screened on the basis of effectiveness, implementability, and cost. Components considered for each of the evaluation criteria are presented in Figure 1-5. Table 6-13 presents the screening process for each alternative. A summary of the alternatives showing the status of each based on initial screening is presented in Table 6-14.

## 6.7 SUMMARY OF CONTAMINATION ASSESSMENT THROUGH REMEDIAL ALTERNATIVES SCREENING

A table was prepared to summarize the previous sections described for the Settling Ponds and Spoils Disposal Area. This is shown in Table 6-15.

# 7.0 SOUTHERN OFF-POST AREA

## 7.1 SITE BACKGROUND AND HISTORY

Based on data from groundwater sampling along the southern BAAP facility boundary, it has been established that the contaminant plume originating at the Propellant Burning Ground has migrated off-post to the south. For a description of the nature of groundwater contamination at the Propellant Burning Ground, refer to Section 3.

This section first summarizes the Southern Off-Post Area geology and groundwater characterization, contamination assessment, and baseline risk assessment described in Section 11.0 of the Final RI Report (ABB-ES, 1993a). Then, based on potential future risks to human receptors at the site, this section develops remedial action objectives and alternatives necessary to address site contamination. The remedial alternatives developed for the Southern Off-Post Area are intended to be protective of human receptors which may currently come into contact with contaminated groundwater. In the unlikely event groundwater contaminants should migrate to public and/or private water supplies, actions outlined in the Off-Post Contingency Plan, prepared by ABB-ES for USAEC, would be implemented. Actions could include well replacement or providing alternate drinking water sources to users of the affected wells.

This section concludes with the screening of remedial alternatives. Those alternatives retained after the screening process will be further evaluated in the detailed analysis presented in Section 13.

## 7.2 GEOLOGY AND GROUNDWATER CHARACTERIZATION

The geologic and hydrogeologic interpretations of the Southern Off-Post Area are based on data presented in the Final RI Report (ABB-ES, 1993a).

### 7.2.1 Geology

Soil borings and monitoring wells installed in the Southern Off-Post Area (Figure 7-1) encountered a near-surface, fine grained loess deposit underlain by approximately 200 to 220 feet of coarse-textured sands and gravel over bedrock.

Bedrock in this area is composed of interbedded sandstones and carbonate units. As this area is located west of the Johnstown Terminal Moraine, the soils appear to be largely outwash materials. No glacial tills were encountered in any soil borings in this area. The orientation of geologic cross sections depicting generalized stratigraphic relationships among the major soil units is presented in Figure 7-2. The cross sections themselves are presented in Figures 7-3, 7-4, and 7-5. The cross sections present only generalized relationships interpreted from conditions encountered in specific borings. Significant changes could occur between soil borings.

At the ground surface, a dark brown to black fine-grained silty soil unit was encountered in nearly all soil borings. This unit is a loess deposit consisting of windblown fine sand, silt, and clay. Boring logs indicate the unit is up to 8 feet thick, although the dual-walled drilling technique used at the site often resulted in limited cuttings return near the ground surface from which to make geologic observations.

Coarse-textured soils were encountered beneath the loess and were typically described as poorly sorted sands with gravels. At some locations, substantial gravel deposits were encountered underlying the loess. At approximate elevation 720 to 740 feet MSL (about 90 to 110 feet bgs), a coarser grained sand and gravel deposit was encountered. The elevation of this unit corresponds well with the coarse-grained gravel unit encountered at depth below the Propellant Burning Ground (see Figure 7-5). B-series monitoring wells were typically screened in this unit.

Below the coarse-grained sand and gravel layer, variably textured sands with gravel approximately 50-to-70 feet thick were again encountered. C-series wells were generally installed in this layer. These sands extended to just above the bedrock surface, where another coarse-grained sand and gravel layer was encountered. D-series wells were generally installed in this lower sand and gravel unit.

Bedrock was encountered at boring SWN-91-03E at 210 feet bgs (approximate elevation 625 feet MSL), and a bedrock monitoring well was installed. A total of 48 feet of bedrock was penetrated for this installation. The top 10 feet of bedrock is described as a blue-gray fine-grained dolomite. This was followed by 15 feet of tan to brown medium-grained sandstone. The final 23 feet of the boring penetrated additional blue-gray dolomite. Monitoring well SWN-91-03E was screened in the sandstone unit.

South of SWN-91-03E, the bedrock dips to an elevation of approximately 610 feet MSL at PBM-90-02D and 590 feet MSL at PBN-90-04D (Figure 7-5).

### 7.2.2 Site Hydrogeology

This subsection describes the hydrogeologic setting of the Southern Off-Post Area. The hydrogeology of this area, as with much of BAAP, is dominated by the highly permeable sand and gravel aquifer in the coarse-grained outwash soils discussed in Subsection 7.2.1.

The silty loess unit at the ground surface likely acts to limit the infiltration of precipitation. Recharge rate estimates based on water budget analysis and low-flow stream discharge records suggest a recharge rate on the order of 5 to 7 inches per year. Below the silty loess, a substantial vadose zone, on the order of 75 feet thick, overlies the water table. Groundwater recharging the aquifer must pass through this unit before reaching the water table.

Horizontal groundwater flow in this area is largely influenced by the WP&L dam on the Wisconsin River. The water level in the Lake Wisconsin Reservoir north of the dam (approximate elevation 774 feet MSL) is substantially higher than the water table elevation in the adjacent sand and gravel aquifer (approximate elevation 760 to 745 feet MSL). This head difference prohibits discharge of groundwater into the reservoir in this area. Rather, groundwater flows south, parallel to the reservoir in this area, before turning east and discharging to the Wisconsin River south of the WP&L dam. As illustrated in Figure 7-6, groundwater flow in the Southern Off-Post Area is within the region where groundwater flow is curving from a southerly flow direction to an easterly flow direction.

In this area, where groundwater flow is turning to discharge to the Wisconsin River, flow-lines are generally converging, and to accommodate this, the horizontal gradients are somewhat steeper than in the on-post area. Horizontal gradients measured in this area range from 0.0019 to 0.0030 ft/ft. Steeper gradients were measured between the wells located closer to the WP&L dam while the flatter gradients were measured between wells located further from the WP&L dam.

Vertical gradients measured at the various well nests indicate no substantial upward or downward flow components. This was expected, given the coarse, relatively homogeneous nature of the aquifer materials. The maximum vertical gradient measured is only 0.004 ft/ft (measured at well clusters PBM/N-90/91-01C and D and

PBM/N-90/91-02C and D). Minor vertical gradients such as these could reflect slightly different flow velocities between different layers or variations in the precision of the water level measurement.

Upward vertical flow gradients are expected near the WP&L dam and between the bedrock and overburden groundwater flow systems. Upward vertical gradients are expected adjacent to, and downgradient of, the WP&L dam where groundwater is flowing upward to discharge into the Wisconsin River. Given the gradients measured at the SWN-91-05 and PBN-90/91-01 well clusters, it appears the upward gradients associated with the WP&L dam do not extend to this area. General upward vertical gradients were expected from the underlying bedrock into the overburden flow system as the deep regional bedrock flow system also discharges to the Wisconsin River. However, upward gradients were not detected at SWN-91-03D and E where wells are screened in the overburden and bedrock, respectively. Apparently, at this location, the water levels in the bedrock flow system more closely reflect the water levels in the overburden flow system than the deeper bedrock flow system. It is likely that upward gradients would exist at deeper depths in the bedrock flow system.

Hydraulic conductivity tests were performed at monitoring wells SWN-91-03B, C, D, and E by ABB-ES. The test results indicate a highly permeable aquifer with hydraulic conductivity values ranging from $1 \times 10^{-2}$ to $2 \times 10^{-2}$ cm/sec. These results are consistent with the slug test results obtained from on-post monitoring wells at BAAP. The extraction well (BCW-3) aquifer test performed in the southern Propellant Burning Ground indicated a somewhat higher hydraulic conductivity of $6.9 \times 10^{-2}$ cm/sec. The slug test conducted at SWN-91-03E indicates a hydraulic conductivity of $1.0 \times 10^{-3}$ cm/sec in the underlying bedrock aquifer. The results suggest the sandstone bedrock aquifer has a slightly lower hydraulic conductivity than the overburden aquifer.

Groundwater flow velocities for the overburden aquifer were calculated using the horizontal gradient data and the hydraulic conductivity test results presented above. The calculations indicate a groundwater flow velocity range of 80 to 680 feet/year. This range is comparable to, although somewhat higher than, the on-post flow velocities calculated at BAAP. The higher velocities reflect the steepened gradients and the converging flow lines associated with groundwater flow around the WP&L dam.

An aquifer performance test completed by Woodard-Clyde in December, 1993 at the BAAP Southern Boundary resulted in a hydraulic conductivity of 340 feet/day ($1.2 \times 10^{-2}$ cm/sec) (Woodard-Clyde, 1994a).

### 7.3 CONTAMINATION ASSESSMENT SUMMARY

The groundwater contamination assessment summary is based on data presented in the Final RI Report (ABB-ES, 1993a).

Two separate groundwater sampling events were undertaken by ABB-ES at BAAP. During the first event in September and October of 1990, two limited rounds of groundwater samples (1990 Round I and 1990 Round II) were collected from selected wells (PBM-90-01D, PBM-90-02D, PBM-90-03D, and PBN-90-04B,D) in the Southern Off-Post Area. Samples were collected from the five monitoring wells and analyzed for the following VOCs: 11DCE, 11DCLE (Round II only), 12DCE, 12DCLE (Round II only), CCL4, CHCL3, and TRCLE. Only select VOCs were analyzed in an attempt to more clearly define the off-post VOC plume. During the second event, two complete rounds of groundwater samples were collected in November and December of 1991 (Round One) and April and May of 1992 (Round Two) from all monitoring wells located in the Southern Off-Post Area. As required in the WDNR In-Field Conditions Report, the sampling program also included three residential water supply wells (i.e., Graf, Premo, and Schaefer) south of BAAP (WDNR, 1987). Groundwater samples were analyzed for VOCs, SVOCs (including NG, 24DNT, 26DNT, and NAMs in samples from the Premo and Schaefer wells), anions, CD, CR, HG, and PB. Groundwater samples from SWN-91-03E, Premo, Schaefer, and Graf wells were analyzed for toxic analyte list metals. Additionally, all wells were analyzed for total hardness (HARD), alkalinity (ALK), and total dissolved solids (TDS).

Groundwater beneath the Southern Off-Post Area has been shown to be contaminated with VOCs (i.e., CCL4, TRCLE, and CHCL3). Sampling locations and a summary of VOC groundwater data are shown in Figure 7-7. Generally, the results indicate very low to trace concentrations of VOCs. The outer well clusters established along the northern transect (SWN-91-01B, C and D and SWN-91-05B, C, and D) and the southern transect (PBM/N-90/91-01C and D and PBN-90-04B and D) delineate the maximum lateral boundaries of the plume. Based on the results obtained from SWN-91-03 and PBM/N-90/91-02 well clusters, the boundaries of the plume can be narrowly defined, as shown in Figure 7-7. Vertically, the plume appears to be contained within the overburden aquifer. Samples collected from

bedrock monitoring well SWN-91-03E near the centerline of the plume have not detected any site-related VOCs (ABB-ES, 1993a). No site-related SVOCs were detected in the Southern Off-Post Area.

CR, CD, and PB were detected above Wisconsin standards in groundwater samples from the Southern Off-Post Area. It appears that CR, detected only in Round One samples, is the result of a laboratory bias (ABB-ES, 1993a). Detections of CD and PB were sporadic, indicating these metals occur naturally in the groundwater and are not likely occurring as a contaminant plume.

NIT was the only anion detected at concentrations above Wisconsin standards in the Southern Off-Post Area. The NIT concentrations appear to reflect region-wide cultural practices (e.g., agriculture, septic systems). No BAAP site-related NIT plume can be associated with these results.

Review of BAAP quarterly groundwater data through September 1992 from the Southern Off-Post Area private wells and monitoring wells are generally in agreement with the RI data. One notable difference is the detection of CCL4 in BAAP samples taken in October 1992 from wells SWN-91-02C,D, SWN-91-03E, SWN-91-04C, and PBN-91-02C. CCL4 was not detected in these wells during the two RI sampling rounds.

## 7.4 Development of Remedial Action Objectives

The baseline risk assessment for the Southern Off-Post Area presented in the Final RI Report included a human health evaluation and an ecological assessment (ABB-ES, 1993a). This subsection presents the COCs and summarizes the risks to human and ecological receptors identified in the RI report. The remedial action objectives developed in this subsection are designed to reduce the risks posed by site contaminants to acceptable levels.

### 7.4.1 Summary of Human Health Evaluation

Groundwater is the contaminated medium that humans might be exposed to at the Southern Off-Post Area. Groundwater quality was compared to federal and state standards. In addition, an exposure scenario which includes a farm worker adjusting irrigation equipment was qualitatively evaluated.

**7.4.1.1 Selection of Human Health Contaminants of Concern.** HCOCs are chemicals with inherent toxic/carcinogenic effects that are likely to pose the greatest threat to human receptors. HCOCs are present in groundwater at the Southern Off-Post Area.

**7.4.1.2 Human Health Risk Characterization.** Contaminant concentrations in groundwater exceed groundwater standards. Table 7-1 summarizes the chemicals detected in the groundwater, the frequency of detection, and the minimum and maximum detected concentrations. Concentrations of CCL4 and NIT exceed MCLs and WESs. Concentrations of CHCL3, CR, PB, and TRCLE are below WESs but exceed WPALs. Additionally, concentrations of MN exceed secondary drinking water standards.

The deeper portion of the sand and gravel aquifer in the Southern Off-Post Area is a source of water for spray irrigation of crops. Because the CCL4 plume is present in the deeper portion of the aquifer, potential exists for a farm worker adjusting irrigation equipment to have contact with contaminated groundwater. Contact is assumed to be infrequent and of short duration, occurring during set-up and adjustment of equipment. Because the exposure parameters are difficult to quantify, risk to the farm worker was evaluated by comparing the nature of the exposure to risks calculated for a standard residential exposure to the same contaminants. It should be noted that this residential exposure does not occur at the present time nor is it expected to occur in the future; it is calculated to compare to a possible irrigation exposure only. Risk estimates calculated for residential exposures are very conservative and assume groundwater ingestion and inhalation of vapors for a duration of 350 days per year for 24 years. The total carcinogenic risk for ingestion and inhalation is $3x10^{-5}$, falling within the USEPA target range. The HI is potentially above the target level of 1.0, depending upon the RfD used for nitrate, which is the only contributor to acute risk. Based on these extremely conservative results for long-term, repetitive contact, it appears that a farm worker would incur no additional risk inasmuch as the worker is exposed only infrequently and then only through the inhalation route.

### 7.4.2 Summary of Baseline Ecological Assessment

The potential effects of bioaccumulation of the primary organic groundwater contaminants (i.e., CCL4, CHCL3, and TRCLE) were assessed. Exposure of biota to groundwater contaminants would occur via irrigation of crops.

Various studies report strong correlation between the tendency for compounds to bioconcentrate in biological tissue and the respective octanol-water partition coefficients ($K_{ow}$) (Veith et al., 1979). Empirical evidence suggests that food chain magnification is likely only for certain organic compounds, such as polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT), which have partition coefficients of $10^{-5}$ or greater (Rand and Petrocelli, 1985). Coefficients for the compounds detected in the groundwater plume are several orders of magnitude lower, ranging from less than $10^{-0}$ to $10^{-2}$. Consequently, it is not considered likely that these compounds would concentrate in biota.

### 7.4.3 Identification of Remedial Action Objectives - Groundwater

There are no ecological risks associated with groundwater. The human health evaluation indicates the following:

- concentrations of CCL4 and NIT exceed MCLs, WESs, and WPALs;
- concentrations of CHCL3, CD, PB, and TRCLE are below WESs but exceed WPALs; and
- concentrations of MN exceed secondary drinking water standards and public welfare standards.

Based on the site conditions, nature of the contaminants, migration pathways, and the conclusions of the human health evaluation, the following remedial action objective for contaminated groundwater has been formulated:

- prevent concentrations of CCL4, CHCL3, TRCLE, CD, and PB in groundwater which exceed WPALs from becoming available to potential human receptors.

Reducing exposure to or contact with the above constituents in groundwater would be protective of farm workers, the only receptors potentially exposed to contaminated groundwater. Although concentrations of CCL4 exceed the MCL, WES, and WPALs reducing CCL4 concentrations would not be warranted because: 1) The RI data indicate that CCL4 is not present in sufficient concentrations to present unacceptable carcinogenic or acute risks (as demonstrated for the residential exposure scenario discussed above), and; 2) groundwater extraction will be implemented at the southern

boundary of BAAP (i.e., Propellant Burning Ground), preventing further CCL4 contamination from entering the Southern Off-Post Area.

Although NIT concentrations exceed the MCL, the WES, and WPAL, agricultural practices, rather than past BAAP production and waste disposal, is the likely source of the high NIT concentrations in groundwater at the Southern Off-Site Area. The Wisconsin Groundwater Quality Standards provide exemptions from regulations for similar situations. As described in NR 140.26(4), "If nitrates or any substances of welfare concern only attains or exceeds an enforcement standard, the department is not required to impose a prohibition or close a facility if it determines that: (a) the enforcement standard was attained or exceeded, in whole or in part, because of high background concentrations of the substance, and; (b) the additional concentration does not represent a public welfare concern." Given the land use (i.e., agricultural) in the vicinity of the Southern Off-Post Area and the low potential for groundwater ingestion in this area, an exemption from the WES for NIT is appropriate. As such, remedial action objectives for NIT in groundwater are not being proposed.

The RI data indicate that CHCL3, CR, PB, MN, and TRCLE do not significantly contribute to risk so developing a remedial action objective for these contaminants is not warranted. However, monitoring and reporting CHCL3, CR, PB, MN, and TRCLE concentrations in groundwater would continue during implementation of the remedial action objective for groundwater.

The secondary drinking water standard and the WPAL for MN is a welfare-based standard concerned with the aesthetic quality of water; not based on human-health considerations. Considering the intent of the standard and the RI results which show that the maximum MN concentration (i.e., 54.1 $\mu$g/L) exceeds the secondary standard (i.e., 50 $\mu$g/L) by only a small margin, developing a remedial action objective for MN is not warranted.

### 7.5 Identification and Screening of Remedial Technologies

This subsection identifies and screens remedial technologies for groundwater remediation at the Southern Off-Post Area. A description of the technology identification and screening process is presented in Subsection 1.7. The result is an inventory of technologies retained for developing remedial alternatives. Remedial alternatives development and initial screening is presented in Subsection 7.6. Experience gained during the development of remedial alternatives for the Propellant

Burning Ground was utilized to limit the number of alternatives for the Southern Off-Post Area.

### 7.5.1 Remedial Technology Identification and Screening

Table 7-2 identifies general response actions and remedial technologies potentially applicable to Southern Off-Post Area groundwater. Technology Screening is shown in Table 7-3. Technologies judged not effective nor implementable were eliminated from further consideration. The technologies remaining after screening, summarized in Table 7-4, were subsequently used to develop remedial alternatives.

## 7.6 Development and Initial Screening of Remedial Alternatives

In this subsection, technically feasible remedial technologies (retained after screening in Subsection 7.5) are assembled into a remedial alternative. The remedial alternatives are then screened on the basis of effectiveness, implementability, and cost. A description of the alternatives development process is presented in Subsection 1.5.

### 7.6.1 Remedial Alternatives Development

Three remedial alternatives were developed for groundwater at the Southern Off-Post Area. These include a minimal action alternative and two treatment alternatives (i.e., Air Stripping, Carbon Adsorption). The alternatives are identified in Table 7-5, and described in further detail in Table 7-6. The following paragraphs provide a general discussion of the alternatives.

<u>Minimal Action</u>. The minimal action alternative (i.e., SOPA-GW1) does not include containment or treatment of contaminants. This alternative includes measures to prevent human exposure to groundwater contaminants. Institutional controls (i.e., zoning and deed restrictions) and educational programs would reduce the potential for human exposure to contaminated groundwater. Because contaminants would remain in the aquifer for an indefinite period, long-term management in the form of groundwater monitoring and five-year site reviews is included.

<u>Treatment</u>. Two remedial alternatives (i.e., Air Stripping, Carbon Adsorption) were developed as potential treatments for the Southern Off-Post Area groundwater. Both alternatives include groundwater extraction and discharge of treated groundwater to

the Wisconsin River below the WP&L Dam. Treatment would occur in a dedicated facility located in the Southern Off-Post Area. The two treatment alternatives are described below:

- SOPA-GW2: Air Stripping. Groundwater would be extracted from the Southern Off-Post Area and transported to a new air stripping treatment facility located off-site. The air stripping treatment facility would be designed to remove up to 99% of the VOCs from groundwater prior to its discharge to the Wisconsin River.

- SOPA-GW3: Carbon Adsorption. Groundwater would be extracted from the Southern Off-Post Area and transported to a new carbon adsorption facility located off-site. The carbon adsorption treatment facility would be designed to remove up to 99% of the VOCs from groundwater prior to its discharge to the Wisconsin River.

### 7.6.2 Initial Screening of Remedial Alternatives for Groundwater

The three remedial alternatives developed for the Southern Off-Post groundwater were screened for effectiveness, implementability, and cost. Components considered for each of the evaluation criteria are presented in Figure 1-5. Alternative screening is presented in Table 7-7. Table 7-8 presents the status of each alternative based on initial screening.

## 7.7 SUMMARY OF CONTAMINATION ASSESSMENT THROUGH REMEDIAL ALTERNATIVES SCREENING

A summary of RI/FS components, from identification of contaminants of concern through remedial alternatives retained after screening, is presented in Table 7-9.

## 8.0 REMEDIAL ALTERNATIVES SUMMARY

This section presents the remedial alternatives retained for detailed evaluation for the BAAP sites being considered in this report (i.e., Propellant Burning Ground, Deterrent Burning Ground, Nitroglycerine Pond/Rocket Paste Area, Settling Ponds and Spoils Disposal Area, and Southern Off-Post Area). Sections 3 through 7 of this report each included a separate remedial alternative development and screening evaluation for one of the sites, without documenting potential multiple-site application of the alternatives. Retained remedial alternatives are presented in this section to conveniently show the retained alternatives for each media in a single table, and to illustrate which alternatives have the potential for being implemented at more than one site.

Table 8-1 is a matrix of sites and retained alternatives for soil and sediment remediation. Soil and/or sediment remediation is being considered at all the sites except the Southern Off-Post Area.

Table 8-2 identifies retained alternatives for surface water remediation. Surface water remediation is being evaluated only at the Nitroglycerine Pond/Rocket Paste Area.

Table 8-3 identifies retained alternatives for groundwater remediation. Groundwater remediation is being evaluated at the Propellant Burning Ground, the Deterrent Burning Ground, and the Southern Off-Post Area. The retained groundwater alternatives are the same for the Propellant Burning Ground and the Deterrent Burning Ground.

# 9.0 DETAILED ANALYSIS OF PROPELLANT BURNING GROUND ALTERNATIVES

Remedial alternatives for surface soil, subsurface soil, waste pits, and groundwater remediation at the Propellant Burning Ground are evaluated in this section using seven evaluation criteria recommended in USEPA's RI/FS guidance (USEPA, 1988b). These criteria serve as the basis for the detailed analysis. The criteria are described in Subsection 1.7. The alternatives that are evaluated in this section were retained after initial screening of alternatives in Section 3.

Following the detailed analysis of remedial alternatives for each contaminated media, the relative advantages and disadvantages of each alternative are compared using the evaluation criteria. Comparison of the alternatives leads to the selection of the recommended remedial alternatives for surface soil, subsurface soil, waste pit, and groundwater remediation at the Propellant Burning Ground. The recommended remedial alternatives are presented at the conclusion of each media-specific subsection.

Because surface soil, subsurface soil, waste pits, and groundwater at the Propellant Burning Ground could all eventually require remedial actions which include containment, removal, and/or treatment of contaminated media, and the remedial action for one medium could potentially affect the feasibility of remedial actions for other mediums (e.g., waste pit remedial actions potentially affecting surface soil remedial actions in the Contaminated Waste Area), remediation of the Propellant Burning Ground should proceed according to a master plan. In addition, closure of the open burning unit (i.e., Burning Pads in the Racetrack Area) is being conducted according to a prescribed sequence of activities that have been agreed to by the WDNR and BAAP. A discussion of the potential scope of remedial activities for each environmental medium, when those activities would occur in relation to other activities at the site, and other factors affecting remedial actions is provided in the following paragraphs.

Surface Soil. Activities for surface soil remediation would occur in the Racetrack Area and the Contaminated Waste Area. Surface soil remediation in the Contaminated Waste Area would potentially occur over a 5-acre area which incorporates Waste Pits WP-1, WP-2, and WP-3. Surface soil remediation in the Racetrack Area would potentially occur over a 12-acre area which incorporates the Burning Pads Area, Burning Plates Area, and the Refuse Pits. Although

contaminated soil in the Refuse Pits would normally be categorized as subsurface soil, the small volume of contaminated soil in the Refuse Pits, the location of the Refuse Pits in the Racetrack Area, and contamination (i.e., primarily metals) similar to surface soil contamination suggests that treating contaminated soil from the Refuse Pits with surface soil is the best approach.

Surface soil remediation in the Contaminated Waste Area would be affected by remedial activities at the waste pits. If the surface soil containment or treatment/containment alternative (i.e., Soil Cover and Modified In Situ S/S, respectively) were implemented prior to remediation of the waste pits, the soil cover and underlying untreated soil or treatment residuals in the vicinity of the waste pits would be disturbed by excavation activities and the vehicular traffic associated with excavation and possible construction activities. In addition, the nature of excavation activities may result in accidental dispersal of contaminated waste pit soil over the soil cover. Consequently, considerable rework would be required to repair a damaged and/or contaminated soil cover. From a construction standpoint, remediation of surface soil in the Contaminated Waste area should occur after waste pit remediation has been completed.

Surface soil remediation in the Racetrack Area would be affected by closure of the open burning unit. The closure plan for the open burning unit is expected to be implemented in two phases (Olin Corporation, 1994). Phase I would include the following activities:

- removal of all soils that are characteristic hazardous waste (i.e., those that fail the TCLP test), the burning pads, the burning pans, and all other equipment associated with the burning pads;

- thermal treatment of burning pad material (i.e., concrete), the burning pans, and all other equipment associated with the burning pads in decontamination ovens at BAAP;

- transporting soils that are characteristic hazardous waste to an off-site hazardous waste treatment facility, treat the soils to remove the characteristic, and dispose of the treatment residuals at a facility that is permitted to accept such waste, and;

- perform a treatability study to verify that in-situ stabilization will not allow PB (the primary surface soil contaminant) to leach out of Burning Pad Area soils remaining on site.

Phase II of the closure plan would include the following activities:

- properly manage all Burning Pad Area soils remaining on site that have PB concentrations above 30 mg/kg; and

- submit final closure documentation for the open burning unit to WDNR.

Phase II of the closure plan would be completed by December 31, 1995 and is intended to coincide with remedial activities that will occur during implementation of the preferred surface soil remedial alternative that is presented in Subsection 9.1.5 (Olin Corporation, 1994).

As a consequence of closure plan activities and schedule, activities associated with surface soil remediation in the Racetrack Area would be implemented upon regulatory approval of the preferred alternative for surface soil described in this report. Remedial activities that will occur at other areas (i.e., Contaminated Waste Area, Landfill 1, and the 1949 Pit) would not be significantly impacted by remedial activities at the Racetrack Area, although traffic along access roads could be extremely heavy. Because surface soil remediation in the Contaminated Waste Area would not occur until waste pit remediation is complete, it is anticipated that remedial activities for Contaminated Waste Area and Racetrack Area surface soils would not coincide, and two separate mobilizations for surface soil remediation would be required.

Subsurface Soil: Activities for subsurface soil remediation would occur in Landfill 1 and the 1949 Pit. Subsurface soil remediation at Landfill 1 would potentially occur over an area approximately 300 to 350 feet long by 100 feet wide. The maximum depth of waste material in Landfill 1 is estimated to be 15 feet bgs. Subsurface soil remediation at the 1949 Pit would potentially occur over an area approximately 500 to 550 feet long by 200 to 250 feet wide. The maximum depth of waste material in the 1949 Pit is estimated to be 10 to 15 feet bgs.

Because Landfill 1 is not adjoining any other contaminated areas at the Propellant Burning Ground, subsurface soil remediation at Landfill 1 would not be affected by

other remedial activities. Conclusion: From a construction standpoint, remedial activities at Landfill 1 and the 1949 Pit should coincide so that only one mobilization for subsurface soil remediation is required.

Subsurface soil remediation at the 1949 Pit would be affected by remedial activities at the waste pits, and potentially surface soil at the Contaminated Waste Area. If an alternative involving excavation and/or construction is selected for the waste pits, a very large amount of truck traffic would be traveling between the waste pits and stockpile areas which would likely be located in a relatively level area to the west and southwest of the 1949 Pit. In the event a cap was constructed over the 1949 Pit, the cap could either impede traffic between stockpile areas and the waste pits or would be susceptible to damage if traffic were directed onto and over the cap. In addition, remediation of surface soil associated with the Contaminated Waste Area could extend up to the edge of the 1949 Pit and equipment used during surface soil remediation could damage the cap. In the event the 1949 Pit was excavated, the limits of excavation may extend beyond existing access roads which would be used during waste pit and/or surface soil remediation in the Contaminated Waste Area. From a construction standpoint, remediation of subsurface soil at the 1949 Pit should occur after waste pit and surface soil remediation in the Contaminated Waste Area is completed.

<u>Waste Pits</u>. Activities for waste pit remediation would occur at Waste Pits WP-1, WP-2, and WP-3 in the Contaminated Waste Area. As discussed in Section 3, WP-1 has been backfilled with clean soil while WP-2 and WP-3 remain as open pits approximately 40 feet in diameter and 12 to 15 feet deep. The volume of contaminated soil beneath each waste pit is assumed to be approximately 110 feet in diameter and 100 feet deep.

As was identified in the above discussion of surface soil remediation in the Contaminated Waste Area, waste pit remediation should be completed prior to surface soil remediation in the Contaminated Waste Area. Not only are there construction-related concerns associated with the timing of waste pit remediation, there are also environmental concerns. RI data indicate that the waste pits are a source of groundwater VOC and SVOC contamination. Because several groundwater contaminants currently exceed their respective WPALs and will continue to exceed WPALs for as long as contaminants leach from waste pit soil into groundwater, remedial activities to isolate or remove soil contaminants should be implemented upon regulatory approval of the preferred alternative for the waste pits.

Groundwater. Activities for groundwater remediation at the Propellant Burning Ground would occur downgradient of the source (i.e., Contaminated Waste Area) of groundwater contamination and at the southern BAAP boundary. Remedial activities involve expansion and modification of the existing IRM system for total on-site capture of the Propellant Burning Ground plume. Regulatory approval, subject to the conditions of the Modification of Conditional Plan Approval of In-Field Conditions Report Dated September 14, 1987 and October 30, 1992 Plan Approval Modification for the Interim Remedial Measures (IRM) System Upgrade, of the proposed IRM system upgrade has been received (WDNR, 1993). Events that have occurred since regulatory approval of the proposed IRM system upgrade are noted in Subsection 9.4.

With the possible exception of remedial activities at the waste pits, groundwater remediation would not be affected by other remedial activities at the Propellant Burning Ground. Groundwater remediation would only be affected by remedial activities at the waste pits if In Situ Treatment using soil flushing is implemented. Soil flushing would make use of the existing IRM facility to remove entrained contaminants from the flushing solution. Consequently, treatment facilities may require modification to increase treatment capacity to account for additional flows from soil flushing.

Based upon the above discussion of the potential scope of remedial activities for each environmental medium, when those activities would occur in relation to other activities at the site, and other factors affecting remedial actions (regardless of budgetary constraints), the following order of remedial activities at the Propellant Burning Ground is proposed:

1) The following remedial activities could be implemented concurrently:

    - closure of the open burning unit and remediation of surface soil at the Racetrack Area;
    - remediation of the waste pits at the Contaminated Waste Area;
    - remediation of Landfill 1, and;
    - IRM facility upgrade.

2) Remediation of surface soil at the Contaminated Waste Area.

3) Remediation of the 1949 Pit.

The proposed order of remedial activities at the Propellant Burning Ground could also directly affect scheduling of remedial activities at other BAAP sites (e.g., Deterrent Burning Ground). In the event similar ex-situ treatment alternatives are selected for the Propellant Burning Ground and Deterrent Burning Ground, considerable cost savings could be realized if the alternatives were implemented simultaneously. For example, only one mobilization would be required to treat soil from both sites.

## 9.1 SURFACE SOIL ALTERNATIVES

The following three surface soil remedial alternatives were retained for detailed analysis:

- Minimal Action (PBG-SS1)
- Soil Cover (PBG-SS2)
- Modified In Situ S/S and Soil Cover (PBG-SS6)

Minimal Action was retained because it will serve as a baseline for the other surface soil alternatives. Soil Cover is designed to reduce human health and ecological risks by covering the contaminated soil. Modified In Situ S/S & Soil Cover is designed to reduce risks to potential receptors and degradation of groundwater quality by both treating and covering contaminated soil. These remedial alternatives are described and evaluated in detail in the following subsections.

### 9.1.1 Alternative PBG-SS1: Minimal Action

This subsection describes the minimal action alternative, provides a cost estimate, and evaluates the alternative using the nine evaluation criteria.

**9.1.1.1 Description.** The minimal action alternative is developed to assess impacts on human health and the environment if no remedial actions are implemented. Components of this alternative are as follows:

- perimeter fence with posted warning signs
- institutional controls

- educational programs, including public meetings and presentation
- monitoring program with 5-year site reviews

The key components of this alternative are discussed in the following paragraphs.

Fencing and Warning Signs. A 6-foot-high, chain-link fence with three-strand barbed wire would be installed to discourage passersby. The fence would be installed around the Racetrack and the Contaminated Waste areas as shown in Figure 9-1. The proposed fence is approximately 4,400 linear feet, including a swing gate across the entrances. Warning signs would be posted along the fence at roughly 50-foot intervals as well as at the entrance gates.

Institutional Controls. At present, the Army has no plans to designate the area within BAAP for residential or public use. This component of the minimal action alternative is included only for consideration in the event the Army should decommission the facility and transfer it to the public. Institutional controls in the form of deed or zoning restrictions would be implemented as necessary to restrict residential or public use of the site. Legal ramifications associated with instituting property deed restrictions would need to be coordinated with appropriate Army officials, WDNR, and the City of Baraboo.

Educational Programs. This component includes public meetings and presentations to keep the public informed of the site status. Site status refers to both the general condition of the site and remaining contaminant levels.

Monitoring Program. Under CERCLA 121c, remedial action that results in hazardous substances, pollutants, or contaminants remaining on site must be reviewed at least every five years. Data collected during the monitoring program would help establish whether human health and the environment are protected. If appropriate, remedial action may be initiated.

The monitoring program would be implemented to determine the existing levels of contaminants and evaluate the potential migration of surface soil contaminants from the Propellant Burning Ground.

The groundwater monitoring program implemented would be a continuation of the ongoing monitoring program defined in the October 30, 1992 "Modification of Conditional Plan Approval of In-field Conditions Report" (WDNR, 1992) attached in Appendix D.1. The purpose of this BAAP-wide sampling and analysis program

is to monitor contamination migration and assess future environmental impacts. A description of monitoring locations, analytical parameters, and monitoring frequency pertinent to the Propellant Burning Ground are presented in conjunction with the minimal action alternative (i.e., PBG-GW1) for groundwater. Minimal Action for groundwater is presented in Subsection 9.4.1.

**9.1.1.2 Cost Estimate.** For cost-estimating purposes, the following assumptions were made:

- 4,400 linear feet of fencing
- two swing gates
- 89 warning signs
- $10,000 for institutional controls
- $5,000 per year for 30 years of educational programs

Note: Although groundwater monitoring and five-year site reviews are required components of this alternative, their costs are included in the groundwater remedial alternative estimates (see Subsection 9.4).

The cost estimate for this alternative is shown in Table 9-1. Cost, material usage, and vendor information are provided in Appendices D.2, D.3, and D.4, respectively.

Alternative Evaluation. The assessment of this alternative against the evaluation criteria is presented in Table 9-2.

### 9.1.2 Alternative PBG-SS2: Soil Cover

This subsection describes the soil cover alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the nine evaluation criteria.

**9.1.2.1 Description.** The soil cover alternative consists of a 2-foot soil cover constructed over portions of the Racetrack Area and the Contaminated Waste Area where concentrations of 24DNT, CPAH, AS, PB, CU, HG, SE, and ZN in surface soil exceed RG concentrations. Figure 9-2 shows the proposed areal extent of the soil covers over the Racetrack Area (12 acres) and the Contaminated Waste Area (5 acres). The alternative is designed to meet most (i.e., protection of human health and ecological receptors) of the remedial action objectives for surface soil. The key components of the alternative are:

- site preparation and mobilization
- contaminated soil delineation
- soil cover construction
- surface water management
- post-closure maintenance
- institutional controls (see Subsection 9.1.1.1)
- groundwater monitoring (see Subsection 9.4.1.1)
- five-year site reviews (see Subsection 9.4.1.1)

Institutional controls, groundwater monitoring, and five-year site reviews for this alternative would be similar to those discussed in Subsections 9.1.1.1 and 9.4.1.1. However, institutional controls would have the added purpose of protecting the soil cover from invasive activities. Other key components are discussed in the following paragraphs. The alternative design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

Site Preparation. A stockpile area for cover soils (i.e., common borrow and topsoil) would be established west of the 1949 Pit Area (see Figure 9-2). The area would be large enough to provide sufficient volume for several days of filling and grading operations in the event delivery from the sources is interrupted. A parking area for a mobile laboratory, construction-support trailers, and heavy equipment would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot (see Figure 9-2).

Equipment mobilized to the site would include earth-moving equipment (i.e., backhoes, front-end loaders, and bulldozers), dumptrucks, and construction-support trailers.

Contaminated Soil Delineation. Contaminated surface soil at the Racetrack Area was well-delineated during the RI and additional delineation would not be required. However, contaminated soil delineation would be required at the Contaminated Waste Area. PB is the primary surface soil contaminant at the Contaminated Waste Area. The other surface soil contaminants (i.e., 24DNT, CPAH, AS, CU, HG, SE, and ZN) are co-located with PB. Consequently, the areas requiring remediation would be delineated using the RG for PB (i.e., 30 mg/kg) as the preliminary contamination boundary. To finalize the contamination boundary, additional samples would be collected at the preliminary contamination boundary and analyzed off-site in a certified laboratory to ensure the RGs for all the contaminants have been achieved. A mobile laboratory equipped with an atomic absorption spectrometer

would be parked at the site and used to provide quick analysis of the soil samples during the delineation.

Soil Cover Construction. The entire area within the boundary established during the contaminated soil delineation would be covered. The soil cover system would consist of a compacted 1.5-foot common borrow soil layer under a 6-inch layer of topsoil seeded to establish a vegetative cover. A typical soil cover cross section is shown in Figure 9-3.

Soil would be transported either directly to the contaminated areas or from the on-site stockpile to the contaminated areas. The cover would be spread and graded using conventional construction equipment (e.g., tracked bulldozer). Pitted areas (i.e., WP-2 and WP-3) would be filled in the process of constructing the cover system or would be remediated by one of the alternatives evaluated in Subsection 9.3. A total of approximately 55,000 cubic yards of common borrow and 16,000 cubic yards of topsoil would be needed to construct the cover systems over the Racetrack Area and the Contaminated Waste Area.

To preclude the need for a decontamination pad at the site, every effort would be made to prevent vehicle contact with contaminated soil during cover construction. This would be accomplished by restricting vehicles to areas of the construction site where cover material has been placed and compacted.

Surface Water Management. Ditches would be excavated around the perimeter of the covered areas to divert surface water run-on and reduce soil cover erosion (see Figure 9-2). The ditches would be designed to convey runoff from a 25-year storm event.

To promote runoff from the soil covers, the covers would be sloped no less than 3 percent. The perimeter of the soil covers would be limited to a maximum slope of 3 to 1 to prevent cover erosion (see Figure 9-3).

Post-Closure Maintenance. Post-closure maintenance would include annual visual inspections and, if necessary, performing cover repair. Repairs would be required if the covers were damaged by burrowing animals, vehicular traffic, erosion, or loss of vegetation. Cover vegetation would be mowed on an annual basis to prevent trees from taking root and damaging the covers.

**9.1.2.2 Cost Estimate and Sensitivity Analysis.** For cost-estimating purposes, the following assumptions were made:

- 2-acre stockpile area
- 0.5-acre parking area
- 100 samples analyzed off-site during contaminated soil delineation
- 12-acre soil cover at Racetrack Area
- 5-acre soil cover at Contaminated Waste Area
- 55,000 cubic yards of common borrow (includes 33 percent swell factor)
- 16,000 cubic yards of topsoil (includes 15 percent swell factor)
- 3,500 feet of ditches constructed along the east side of the Racetrack Area and the Contaminated Waste Area
- 8-hour annual visual inspection
- $10,000 for institutional controls

Note: Although groundwater monitoring and five-year site reviews are required components of this alternative, their costs are included in the groundwater remedial alternative estimates (see Subsection 9.4).

The cost estimate for this alternative is shown in Table 9-3. Cost, material usage, and vendor information are provided in Appendices D.2, D.3, and D.4, respectively. Estimated remediation costs for this alternative are sensitive to a variation of soil cover area. PB contamination at the Racetrack Area was well delineated during the RI but the distribution of surface soil samples collected at the Contaminated Waste Area was not sufficient to obtain an accurate estimate of the extent of contamination (ABB-ES, 1993a). Consequently, the soil cover area at the Contaminated Waste Area could be significantly larger than that assumed (i.e., 5 acres) in the cost estimate for this alternative.

**9.1.2.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 9-4.

### 9.1.3 Alternative PBG-SS6: Modified In Situ S/S and Soil Cover

This subsection describes the modified in situ S/S and soil cover alternative, provides the cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the nine evaluation criteria.

**9.1.3.1 Description.** The modified in situ S/S and soil cover alternative consists of: (1) conducting in situ S/S of surface soil inside the Racetrack and at the Contaminated Waste Area; (2) bulldozing soil exceeding RGs from the Burning Pads Area and the Burning Plates Area into the interior of the Racetrack and over the previously treated soil; (3) using in situ S/S equipment to treat each successive lift of contaminated soil after it has been placed inside the Racetrack; (4) excavating soil exceeding RGs from the Refuse Pits and placing it inside the Racetrack; (5) using in situ S/S equipment to treat soil from the Refuse Pits, and; (6) covering the treated soil with a 2.5-foot soil cover. Because soil exceeding RGs in the Burning Pads Area, Burning Plates Area, and the Refuse Pits is expected to be deeper than the depth capability of in situ S/S equipment, this alternative includes excavation of soil from those areas and placement inside the Racetrack in lifts shallow enough to be treated by in situ S/S equipment. Figure 9-4 shows the proposed areal extent of the treated soil and soil covers over the Racetrack Area and the Contaminated Waste Area. The alternative would be designed to meet all the remedial action objectives for surface soil. Key components of the alternative are:

- treatability testing
- site preparation and mobilization
- contaminated soil delineation
- in situ S/S inside the Racetrack and at the Contaminated Waste Area
- excavation, placement, and treatment of soil from the Burning Pads Area, Burning Plates Area, and Refuse Pits
- confirmatory sampling
- soil cover construction
- surface water management (see Subsection 9.1.2.1)
- post-closure maintenance (see Subsection 9.1.2.1)
- institutional controls (see Subsection 9.1.1.1)

- groundwater monitoring (see Subsection 9.4.1.1)
- five-year site reviews (see Subsection 9.4.1.1)

Institutional controls for this alternative would be similar to that discussed in Subsection 9.1.1.1. However, institutional controls would have the added purpose of protecting the soil cover and treated soil from invasive activities. Surface water management and post-closure maintenance for this alternative would be similar to those discussed in Subsection 9.1.2.1. Groundwater monitoring and five-year site reviews for this alternative are similar to those discussed in Subsection 9.4.1.1. Other key components are discussed in the following paragraphs. The alternative design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

Treatability Testing. A bench-scale treatability test would be required to identify the most effective additives and setting agents for treating Propellant Burning Ground soil. Bench tests would also establish the proper ratio of additives/setting agents to contaminated soil. Analyses of test samples before and after treatment would include TCLP. Tests would also be conducted to identify uniformity of the treated product and its durability. The time required for a bench-scale treatability test is estimated to be two months.

A pilot-scale treatability test may be required to identify the most cost-effective method for mixing the additives and setting agents into the soil. A small plot would be prepared at the Propellant Burning Ground for conducting the pilot test. Various types of equipment would be tested for their potential to produce homogenous mixing at high throughput rates. Additionally, pilot tests would determine whether dry (i.e., powder) or wet (i.e., slurry) application of the additives/setting agents is appropriate for the equipment used during in situ S/S. Analyses during pilot tests would be similar to those conducted during the bench tests. The time required for a pilot-scale treatability test is estimated to be three months.

Site Preparation and Mobilization. A covered storage area for S/S additives and setting agents and a stockpile area for storing cover soil (i.e., common borrow and topsoil) would be established west of the 1949 Pit Area. The proposed storage and stockpile areas are shown in Figure 9-4. Similar to what is recommended for Alternative PBG-SS2, the storage and stockpile areas should be large enough to provide a sufficient volume of materials for several days of operation in the event delivery from the sources is interrupted. A parking area for a mobile laboratory, construction-support trailers, and heavy equipment would be prepared west of the

1949 Pit Area by grubbing, grading, and placing gravel to a minimum depth of 1 foot (see Figure 9-4).

A concrete decontamination pad would be constructed in the parking area (see Figure 9-4). This pad would be used to decontaminate equipment used during in situ S/S activities. The pad would be designed to collect decontamination water in a sump, and to pump the water into a collection tank.

Equipment mobilized to the site could include conventional or specialized tillers for mixing the additives and setting agents into the soil, earth-moving equipment (e.g., backhoes, front-end loaders, and bulldozers), dumptrucks, a mobile laboratory, hoppers for storage of S/S additives and setting agents, and construction-support trailers.

Contaminated Soil Delineation. Although contaminated surface soil at the Racetrack Area was well-delineated during the RI, only ten samples (i.e., PBS-91-109 through PBS-91-118) were collected from deeper depths (i.e., 3 feet to 3.5 feet bgs). Because analysis of four of these samples indicates that soil exceeding RGs is present in shallow subsurface soil at the Racetrack Area, additional contaminated subsurface soil delineation would be required. Delineation of contaminated surface soil and subsurface soil, outside of the waste pits, is required at the Contaminated Waste Area. Only five surface soil samples and no shallow subsurface soil samples were collected outside of the waste pits at the Contaminated Waste Area.

PB is the primary surface soil and shallow subsurface soil contaminant at the Racetrack Area and the Contaminated Waste Area. The other soil contaminants (i.e., 24DNT, CPAH, AS, CU, HG, SE, and ZN) are co-located with PB. Consequently, the areas requiring remediation would be delineated using the RG for PB (i.e., 30 mg/kg) as the preliminary contamination boundary. To finalize the contamination boundary, additional samples would be collected at the preliminary contamination boundary and analyzed off-site in a certified laboratory to ensure the RGs for all the contaminants have been achieved. A mobile laboratory equipped with an atomic absorption spectrometer would be parked at the site and used to provide quick analysis of the soil samples during the delineation.

In Situ S/S Inside the Racetrack and at the Contaminated Waste Area. Assuming the contaminated soil inside the Racetrack and at the Contaminated Waste Area is within the depth capability of in situ S/S equipment, surface soils in those areas would undergo remediation prior to excavation and treatment of other contaminated

areas (i.e., Burning Pads Area, Burning Plates Area, and Refuse Pits). An estimated 27,400 cubic yards of surface soil would require remediation inside the Racetrack and at the Contaminated Waste Area. Because of the large area requiring remediation, an in situ process capable of high throughput is preferred. Several contractors, including Geo-Con, Inc., have equipment that can be used for in situ S/S of surface soil. The method proposed by Geo-Con is explained here as an example of in situ S/S (Geo-Con, Inc., 1993).

Geo-Con would use a modified version of a CAT SF 250 road stabilizer machine to apply a pre-determined mixture of water and cement additives to the soil. The SF 250 is similar to a large farm tiller that has a series of harrows suspended from a carriage. The harrows have hollow stems that apply the metered cement-water mixture in precise amounts. The cement and water is pumped from two trucks that follow the SF 250 and keep pace with the application.

The SF 250 system is capable of stabilizing soils to a depth of 10-12 inches bgs. Geo-Con would propose stabilizing the upper ten inches of soil first. A motor grader would follow behind the SF 250 and push the stabilized material into windrows. The motor grader's blade would be set to only excavate the upper eight inches of stabilized material to allow for an overlap on the second pass to ensure complete coverage. The consistency of the stabilized material would be granular and the material would be easily handled by earth-moving equipment.

The SF 250 would then make the second pass over the contaminated area and stabilize the underlying layer of soils. Once the bottom layer is stabilized, the motor grader would push back the first layer of stabilized soils and regrade the site.

Geo-Con would set up a portable cement batch plant on site to provide storage and support to the stabilization activities. The estimated throughput using the proposed Geo-Con method is approximately 1,000 cubic yards of treated soil per day.

Contaminated surface soil in pitted areas (i.e., WP-2 and WP-3) would be treated using a backhoe equipped with a boom extension. The backhoe bucket would place and mix S/S powder or slurry into the soils on the bottom and sides of the pits.

During in situ S/S activities, an exclusion zone would be established around the contaminated areas (see Figure 9-4). S/S equipment would operate within this zone and would not leave without first undergoing decontamination.

Excavation, Placement, and Treatment of Soil from the Burning Pads Area, Burning Plates Area, and Refuse Pits. Following in situ S/S of surface soil inside the Racetrack and at the Contaminated Waste Area, contaminated surface soil and shallow subsurface soil at the Burning Pads Area and the Burning Plates Area would be bulldozed onto the previously stabilized surface soil inside the Racetrack, graded into lifts, and treated with in situ S/S equipment. A typical cross section of the stabilized soil pile inside the Racetrack is shown in Figure 9-5. Assuming excavations to a depth of 4 feet bgs are necessary to achieve RGs in the vicinity of the former Burning Pads and Burning Plates, and excavations to a depth of 2 feet bgs is necessary to achieve RGs elsewhere outside the Racetrack, an estimated 18,600 cubic yards of contaminated soil would be removed from the Burning Pads Area and Burning Plates Area. The Geo-Con in situ S/S equipment would make one pass for each 8-inch lift of soil placed inside the Racetrack (see Figure 9-5).

In conjunction with placement and treatment of contaminated soil from the Burning Pads Area and the Burning Plates Area, contaminated subsurface soil would be excavated from the Refuse Pits, placed inside the Racetrack in lifts, and treated with in situ S/S equipment. An estimated 700 cubic yards of contaminated soil would be removed from the Refuse Pits.

Assuming excavation and the addition of stabilizing agents results in a swell factor of 50 percent, the total volume of soil placed and treated inside the Racetrack would be approximately 28,000 cubic yards. This would result in a stabilized soil pile with a average height of 8 feet.

Confirmatory Sampling. The on-site mobile laboratory would run tests on the treatment product to ensure that pre-determined Quality Assurance/Quality Control (QA/QC) criteria are being achieved. A sampling frequency (i.e., one sample for a given area) would be specified for initial in situ S/S inside the Racetrack and at the Contaminated Waste Area and for subsequent lifts of soil placed inside the Racetrack. Depending on the in situ S/S method used, QA/QC criteria could include TCLP limits, degree of mixing, or permeability and unconfined compressive strength (if the treatment product is a solidified mass).

Soil Cover Construction. The treated soil pile inside the Racetrack and the treated surface soil at the Contaminated Waste Area would be covered. The soil cover system would consist of a compacted 2-foot common borrow soil layer under a 6-inch layer of topsoil seeded to establish a vegetative cover. The 2.5-foot soil cover is necessary to bury the stabilized soil beneath the 30-inch bgs frost line and protect it

from freeze and thaw cycles (ABB-ES, 1993a). A cross section of the covered stabilized soil pile at the Racetrack Area is shown in Figure 9-5.

Soil cover material would be transported either directly to the construction sites or from the on-site stockpile to the sites. The cover would be spread and graded using conventional construction equipment (e.g., tracked bulldozer). Open excavations and pitted areas (i.e., WP-2, WP-3, and the Refuse Pits) would be filled, where necessary, in the process of constructing the cover systems. An estimated 20,700 cubic yards of common borrow and 4,500 cubic yards of topsoil would be required for cover construction at the Racetrack Area. An estimated 27,000 cubic yards of common borrow and 5,800 cubic yards of topsoil would be required for cover construction at the Contaminated Waste Area.

**9.1.3.2 Cost Estimate and Sensitivity Analysis.** For cost-estimating purposes, the following assumptions were made:

- 2-acre stockpile area
- 40-foot by 80-foot temporary structure
- 0.5-acre parking area
- one concrete decontamination pad
- 200 samples analyzed off-site during contaminated soil delineation
- 20,000 cubic yards in situ S/S at Contaminated Waste Area
- 7,400 cubic yards in situ S/S inside the Racetrack
- 18,600 cubic yards from Burning Pads Area and Burning Plates Area bulldozed and treated inside Racetrack
- 700 cubic yards excavated from Refuse Pits and treated inside Racetrack
- $65 per cubic yard for S/S
- 47,700 cubic yards of common borrow for soil covers (includes 33 percent swell factor)
- 10,300 cubic yards of topsoil for soil covers (includes 15 percent swell factor)
- 8-hour annual visual inspection
- $10,000 for institutional controls

Note: Although groundwater monitoring and five-year site reviews are required components of this alternative, their costs are included in the groundwater remedial alternative estimates (see Subsection 9.4).

The cost estimate for this alternative is shown in Table 9-5. Cost, material usage, and vendor information are provided in Appendices D.2, D.3, and D.4, respectively. Estimated remediation costs for this alternative are sensitive to variations in the volume of soil requiring S/S and soil cover area. PB contamination in surface soil at the Racetrack Area was well delineated during the RI but the distribution of surface soil samples collected at the Contaminated Waste Area and subsurface soil samples collected at both the Racetrack Area and Contaminated Waste Area was not sufficient to obtain an accurate estimate of the extent of contamination (ABB-ES, 1993a). Consequently, S/S volumes and the soil cover area could be significantly larger than that assumed in the cost estimate for this alternative.

**9.1.3.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 9-6.

### 9.1.4 Comparative Analysis of Alternatives

This subsection compares the relative advantages and disadvantages of the surface soil alternatives using the evaluation criteria. A comparative summary is provided in Table 9-7.

**9.1.4.1 Overall Protection of Human Health and the Environment.** Although Alternative PBG-SS1 reduces the potential for human exposure to contaminated soil, fencing around the site would not prevent small mammals (e.g., shrews) from entering the site nor will it prevent predators from consuming prey that has come in contact with contaminated soil. In addition, the contaminated soil would continue to present the threat of degrading groundwater quality. Although the soil cover in Alternative PBG-SS2 would reduce contaminant availability to potential human and ecological receptors, it would not be expected to significantly reduce leachate generation and the resultant threat of degrading groundwater quality. By comparison, only Alternative PBG-SS6 has the potential to both reduce contaminant availability to potential receptors and reduce leachate generation such that groundwater is protected.

**9.1.4.2 Compliance with ARARs.** Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater are contained in the proposed Chapter NR 720 and are being applied to BAAP soil remediation. Because soil contaminants would not be removed or destroyed, none of the alternatives would comply with pathway-specific numeric standards contained in the proposed Chapter NR 720.

However, fencing used in Alternative PBG-SS1, soil cover used in Alternative PBG-SS2, and S/S and soil cover used in Alternative PBG-SS6 could be designed to achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of human health. The performance standard would include eliminating the availability of contaminant concentrations which exceed numeric clean-up standards for protection of human health. By entrapping contaminants in the treatment residual, only Alternative PBG-SS6 could potentially achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of groundwater. All the alternatives would be expected to meet location- and action-specific ARARs during and after remedial activities.

**9.1.4.3 Long-term Effectiveness and Permanence.** The long-term effectiveness and permanence of Alternatives PBG-SS1 and PBG-SS2 for protection of human health would be entirely dependent upon the implementation of plans to administer and maintain the site after remedial actions are complete. Failure to adequately administer and maintain the site could result in significant post-remediation exposure events such as construction-related invasive activities into contaminated soil or uncontrolled erosion of contaminated soil to off-site human receptors. Alternative PBG-SS1 would present a long-term risk to ecological receptors while Alternative PBG-SS2 has potential for maintaining acceptable ecological risk levels. Because Alternatives PBG-SS1 and PBG-SS2 would not be designed to reduce leachate generation, they would not provide long-term protection of groundwater quality. By comparison, Alternative PBG-SS6 would be designed to produce treatment residuals that entrap contaminants in a granular or monolithic matrix which is resistant to long-term degradation by natural processes. In the event construction-related invasive activities occur, or burrowing animals penetrate the soil cover, the chemical and physical properties of the treatment residuals would significantly reduce the exposure potential via receptor ingestion and/or inhalation of particulates. Because the treatment residuals would be resistant to degradation processes, they would provide long-term protection of groundwater.

**9.1.4.4 Reduction in Toxicity, Mobility, and Volume through Treatment.** Only one of the surface soil alternatives (i.e., PBG-SS6) includes soil treatment. Although potential mobility would be reduced by S/S, the volume of contaminated soil would increase by up to 50 percent.

**9.1.4.5 Short-Term Effectiveness.** No adverse impacts to the community or the environment would be experienced during implementation of Alternative PBG-SS1.

Only minor adverse impacts would be experienced during implementation of Alternatives PBG-SS2 and PBG-SS6, and they would only occur in the immediate vicinity of the site.

**9.1.4.6 Implementability.** No implementability concerns are associated with Alternatives PBG-SS1 and PBG-SS2. In situ S/S of surface soils is a developing technology and the process would have to be adapted to the site. Consequently, implementability concerns are associated with Alternative PBG-SS6.

**9.1.4.7 Cost.** Alternative PBG-SS1 has the lowest capital cost (i.e., $108,000) and the lowest present worth operation and maintenance cost (i.e., $169,000) compared to the other alternatives. Alternative PBG-SS6 has the highest capital cost (i.e., $6,860,000) and a present worth operation and maintenance cost of $477,000. Alternative PBG-SS2 has a capital cost (i.e., $1,385,000) that is approximately 20 percent that of Alternative PBG-SS6 and a present worth operation and maintenance cost (i.e., $600,000) that is slightly higher than that of Alternative PBG-SS6.

### 9.1.5 Selection of Preferred Alternative

Alternative PBG-SS6 (i.e., Modified In Situ S/S and Soil Cover) is the preferred alternative for surface soil remediation at the Propellant Burning Ground. It is the only alternative that is capable of achieving all of the remedial action objectives and it is the only alternative that could be designed to achieve performance standards for meeting the intent of the proposed Chapter NR 720. Because the chemical and physical properties of the S/S treatment residuals would significantly reduce the exposure potential via receptor ingestion and/or inhalation of particulates, Alternative PBG-SS6 would provide long-term protection of human and ecological receptors. The S/S treatment residuals would also be resistant to degradation by natural processes and would provide long-term protection to groundwater. Although there are some implementability concerns associated with Alternative PBG-SS6, bench-scale treatability tests are expected to identify effective additives and setting agents for treating surface soil and pilot-scale tests would determine the best method for mixing additives and setting agents into the soil.

## 9.2 SUBSURFACE SOIL ALTERNATIVES

The following three subsurface soil remedial alternatives were retained for detailed analysis:

- Minimal Action (PBG-SB1)
- Capping (PBG-SB2)
- Off-Site Landfill (PBG-SB3)

Minimal Action was retained because it has potential for protecting human health and would be easily implemented. Capping is designed to reduce leachate generation and protect groundwater in addition to protecting human health. Off-site Landfill is designed to protect human health and groundwater by removing the contaminated subsurface soil from the Propellant Burning Ground. These remedial alternatives are described and evaluated in detail in the following subsections.

### 9.2.1 Alternative PBG-SB1: Minimal Action

This subsection describes the minimal action alternative, provides a cost estimate, and evaluates the alternative using the nine criteria.

**9.2.1.1 Description**. The minimal action alternative is developed to assess impacts on human health and the environment if no remedial actions are implemented. Components of this alternative are as follows:

- institutional controls
- educational programs, including public meetings and presentations
- monitoring program with 5-year site reviews

The key components of this alternative are discussed in the following paragraphs.

<u>Institutional Controls</u>. Institutional controls in the form of deed or zoning restrictions would be implemented to prohibit any invasive activities into Landfill 1 and the 1949 Pit. At present, the Army has no plans to designate areas within BAAP for residential or public use. In the event that the Army does decommission the facility and transfer it to the public, institutional controls in the form of deed and zoning restrictions would be implemented to restrict residential or public use of the site. The legal ramifications associated with instituting property deed restrictions will be coordinated with appropriate Army officials, WDNR, and the City of Baraboo.

Educational Programs. This component includes public meetings and presentations to keep the public informed of the site status. Site status refers to both the general condition of the site and remaining contaminant levels.

Monitoring Programs. Under CERCLA 121c, remedial action that results in hazardous substances, pollutants, or contaminants remaining on site must be reviewed at least every five years. Data collected during the monitoring program would aid in establishing whether public health continues to be adequately protected. If appropriate, additional remedial action may be initiated.

The monitoring program would be implemented to evaluate the potential migration of subsurface soil contaminants from the Propellant Burning Ground to the underlying aquifer.

The groundwater monitoring program to be implemented will be a continuation of the ongoing monitoring program defined in the October 30, 1992 "Modification of Conditional Plan Approval of In-field Conditions Report" (WDNR, 1992) attached in Appendix D.1. The purpose of this BAAP-wide sampling and analyses program is to monitor contamination migration and assess future environmental impacts. A description of monitoring locations, analytical parameters, and monitoring frequency pertinent to the Propellant Burning Ground are presented in conjunction with the Minimal Action Alternative (i.e., PBG-GW1) for groundwater. Minimal Action for groundwater is presented in Subsection 9.4.1.

**9.2.1.2 Cost Estimate.** For cost-estimating purposes, the following assumptions were made:

- $10,000 for institutional controls
- educational programs, $5,000 per year for 30 years

NOTE: Although groundwater monitoring and five-year site reviews are required components of this alternative, their costs are included in the groundwater remedial alternative estimates (see Subsection 9.4).

The cost estimate for this alternative is shown in Table 9-8.

**9.2.1.3 Alternative Evaluation.** The assessment of this alternative against the evaluation criteria is presented in Table 9-9.

### 9.2.2 Alternative PBG-SB2: Capping

This subsection describes the capping alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the nine evaluation criteria.

**9.2.2.1 Description.** The capping alternative consists of constructing RCRA caps over Landfill 1 and the 1949 Pit. Figure 9-6 shows the approximate locations of the RCRA caps. Key components of the alternative are:

- roadway improvement
- site preparation and mobilization
- contaminated soil delineation
- cap construction
- post-closure maintenance
- institutional controls (see Subsection 9.2.1.1)
- groundwater monitoring (see Subsection 9.4.1.1)
- five-year site reviews (see Subsection 9.4.1.1)

Institutional controls for this alternative would be similar to that discussed in Subsection 9.2.1.1. However, institutional controls would have the added purpose of protecting the caps from invasive activities. Groundwater monitoring and five-year site reviews for this alternative would be similar to those discussed in Subsection 9.4.1.1. Other key components are discussed in the following paragraphs. The alternative design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

<u>Roadway Improvement</u>. The existing access road (see Figure 9-6) to Landfill 1 is a primitive dirt road. The road would be improved to support heavy trucks during transport of material and equipment to the site. Roadway improvements would include constructing a gravel base to a minimum depth of 2 feet and a minimum width of 24 feet. The road surface would be sloped to promote drainage.

<u>Site Preparation and Mobilization</u>. Portions of Landfill 1 have become overgrown with trees. The trees would have to be cleared prior to any construction at Landfill 1.

Stockpile areas for cap materials (i.e., clay, drainage sand, common borrow, and topsoil) would be established adjacent to each location (i.e., Landfill 1 and the 1949

Pit). The proposed stockpile areas are shown in Figure 9-6. The areas would be large enough to provide sufficient volume for several days of cap construction in the event delivery from the sources is interrupted. A parking area for heavy equipment and a construction-support trailer, located adjacent to each stockpile area, would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot (see Figure 9-6). One of the parking areas would also accommodate a mobile laboratory.

Equipment mobilized to the site would include earth-moving equipment (i.e., front-end loaders and bulldozers), dumptrucks, construction-support trailers, and a mobile laboratory.

Contaminated Soil Delineation. The contaminated soil delineation would consist of soil sampling outside the waste boundary to determine the areal extent of soil contamination. PB is the primary subsurface soil contaminant at Landfill 1 and the 1949 Pit. The other subsurface soil contaminants (i.e., 24DNT, 26DNT, CPAH, C6H6, TRCLE, AS, CR, SE, and ZN) are co-located with PB. Consequently, the areas requiring capping would be delineated using the RG for PB (i.e., 3.97 mg/kg) as the preliminary contamination boundary. To finalize the contamination boundary, additional samples would be collected at the preliminary contamination boundary and analyzed off site in a certified laboratory to ensure the RGs for all the contaminants have been achieved. Delineation would be conducted using a subsurface sampling device (e.g., split-spoons). A mobile laboratory equipped with an atomic absorption spectrometer would be parked at one of the sites to provide quick analysis of soil samples during the delineation.

Cap Construction. Multilayered caps would be installed over Landfill 1 and the 1949 Pit. The cap at Landfill 1 would cover approximately 1 acre and the cap at the 1949 Pit would cover approximately 3 acres. Figure 9-7 shows a typical cap construction cross section at one of the sites. The caps would be constructed of the following materials (from the bottom up):

- compacted clay layer
- 60-mil flexible membrane liner
- sand drainage layer
- filter fabric
- compacted common borrow layer
- topsoil layer

After an appropriate base grade has been established, a 2-foot layer of clay, compacted to achieve a hydraulic conductivity of $1x10^{-7}$ cm/sec or less, would be placed over the area. Following placement of the clay layer, a 60-mil flexible membrane liner would be placed over the entire clay layer and anchored into the existing soil at the perimeter of the clay layer. A 1-foot layer of drainage sand would be placed over the flexible membrane liner. The permeability of the drainage layer would be $5x10^{-3}$ cm/sec or greater. Filter fabric would be placed over the drainage sand to prevent the migration of fines from the common borrow and topsoil layers into the drainage layer. A 2-foot layer of common borrow would be placed and compacted over the filter fabric. The 2-foot layer of common borrow, in conjunction with the 1-foot topsoil layer, would provide protection against frost penetration. The topsoil layer would be fertilized and seeded to provide a good vegetative cover. Each cap would taper on all sides with an average slope of 5:1 (see Figure 9-7).

Post-Closure Maintenance. Post-closure maintenance would include annual inspections and, if necessary, performing cap repair. Repairs would be required if the caps have been damaged by burrowing animals, vehicular traffic, or loss of vegetation. Cap vegetation would be mowed on an annual basis to prevent trees from taking root and damaging the caps.

**9.2.2.2 Cost Estimate and Sensitivity Analysis.** For cost-estimating purposes, the following assumptions were made:

- 800 square yards of improved roadway surface at Landfill 1
- 1-acre stockpile area at each location for cap materials
- 0.25-acre parking area at each location
- 50 samples analyzed off site during contaminated soil delineation
- 1-acre cap at Landfill 1
- 3-acre cap at the 1949 Pit
- 8-hour annual visual inspection
- $10,000 for institutional controls

NOTE: Although groundwater monitoring and five-year site reviews are required components of this alternative, their costs are included in the groundwater remedial alternative estimates (see Subsection 9.4).

The cost estimate for this alternative is shown in Table 9-10. Cost, material usage, and vendor information are provided in Appendices D.2, D.3, and D.4, respectively. Estimated remediation costs for this alternative are sensitive to a variation in the

areal extent of soil contamination at Landfill 1 and the 1949 Pit. The distribution of soil samples collected at Landfill 1 and the 1949 Pit during the RI was not sufficient to obtain an accurate estimate of the areal extent of contamination (ABB-ES, 1993a). Consequently, the contaminated areas could be significantly smaller, or larger, than that assumed (i.e., 1 acre at Landfill 1 and 3 acres at the 1949 Pit) in the cost estimate for this alternative.

**9.2.2.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 9-11.

### 9.2.3 Alternative PBG-SB3: Off-Site Landfill

This subsection describes the off-site landfill alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the nine evaluation criteria.

**9.2.3.1 Description.** The off-site landfill alternative consists of removing subsurface soil containing concentrations of 24DNT, 26DNT, CPAH, C6H6, TRCLE, AS, CR, SE, and ZN exceeding RG concentrations from Landfill 1 and the 1949 Pit and transporting the contaminated soil off site for landfill disposal. Figure 9-8 shows the areas encompassed by Landfill 1 and the 1949 Pit. The alternative would be designed to meet the remedial action objective for subsurface soil. The key components of the alternative are:

- roadway improvement (see Subsection 9.2.2.1)
- site preparation and mobilization
- contaminated soil delineation
- excavation of contaminated soil
- backfill excavations
- transport contaminated soil to off-site landfill

Roadway improvement for this alternative would be similar to that discussed in Subsection 9.2.2.1. Other key components for this alternative are discussed in the following paragraphs. The alternative design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

Site Preparation and Mobilization. Portions of Landfill 1 have become overgrown with trees. The trees would have to be cleared prior to any remediation at the site.

An area for stockpiling excavated soil and debris would be established adjacent to each of the excavation sites (i.e., Landfill 1 and the 1949 Pit). The proposed stockpile areas are shown in Figure 9-8. Because the excavated soil is potentially a RCRA hazardous waste (i.e., potentially failing the TCLP test for PB), the stockpile areas would be designed and constructed to meet regulatory requirements for temporary storage of hazardous waste. These requirements would include lining and berming the stockpile areas to contain runoff from stockpiled soil. A parking area for heavy equipment and a construction-support trailer, located adjacent to each stockpile area, would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot (see Figure 9-8). One of the parking areas would also accommodate a mobile laboratory.

A concrete decontamination pad would be constructed in each parking area (Figure 9-8). The pads would be used to decontaminate trucks loaded with contaminated soil as they leave the sites and would also be used to decontaminate heavy equipment used during excavation. The pad would be designed to collect the decontamination water in a sump, and to pump or gravity-drain the water into a collection tank.

Equipment mobilized to each site would include earth-moving equipment (i.e., backhoes, front-end loaders, and bulldozers), dumptrucks, construction-support trailers, and a mobile laboratory.

Contaminated Soil Delineation. The contaminated soil delineation would consist of sampling soil in the debris zone and in the zones adjacent to and beneath the debris. PB is the primary subsurface soil contaminant at Landfill 1 and the 1949 Pit. The other subsurface soil contaminants (i.e., 24DNT, 26DNT, TRCLE, AS, CR, SE, and ZN) are co-located with PB. Consequently, the areas requiring excavation would be delineated using the RG for PB (i.e., 3.97 mg/kg) as the preliminary contamination boundary. To finalize the contamination boundary, additional samples would be collected at the preliminary contamination boundary and analyzed off site in a certified laboratory to ensure the RGs for all the contaminants have been achieved. Delineation would be conducted using a subsurface sampling device (e.g., split-spoons). A mobile laboratory equipped with an atomic absorption spectrometer would be parked at one of the sites to provide quick analysis of soil samples during the delineation.

Excavation of Contaminated Soil. Contaminated soil would be excavated from Landfill 1 and the 1949 Pit using backhoes. Debris that is encountered during

excavation would be segregated and stockpiled separate from the contaminated soil. Dumptrucks equipped with liners would transport the soil and debris to the stockpile areas.

During excavation activities, an exclusion zone would be established around the excavation and stockpile areas (see Figure 9-8). Excavation and handling equipment would operate within this zone and would not leave without first undergoing decontamination.

Backfill Excavations. Following removal of contaminated soil and debris, stockpiled overburden and clean fill would be placed in the excavations, compacted to reduce settlement, and sloped to drain away from the excavation sites.

Transport Contaminated Soil and Debris to Off-Site Landfill. Contaminated soil and debris would be characterized as required by the receiving off-site landfill prior to shipment. Contaminated soil and debris would be transported to the off-site landfill in bulk trailers equipped with liners. Treatment at the landfill would be required if analyses indicate that the soil is characteristically hazardous waste (e.g., exceeds TCLP threshold for PB).

**9.2.3.2 Cost Estimate and Sensitivity Analysis.** For cost-estimating purposes, the following assumptions were made:

- 800 square yards of improved roadway surface at Landfill 1
- 1-acre hazardous waste stockpile area at the 1949 Pit
- 0.5-acre hazardous waste stockpile are at Landfill 1
- two 0.25-acre parking areas
- two concrete decontamination pads
- 75 samples analyzed off site during contaminated soil delineation
- 2,650 cubic yards removed from the 1949 Pit
- 1,400 cubic yards removed from Landfill 1
- 5,450 cubic yards (6,550 tons) total requires off-site disposal (includes 33 percent swell factor)
- 108-mile one-way trip to off-site landfill (Menomonee Falls, WI)
- $4.75 per loaded mile
- $100 per trip unloaded fee
- $142.50 per ton for treatment (S/S) and disposal

The cost estimate for this alternative is shown in Table 9-12. Cost, material usage, and vendor information are provided in Appendices D.2, D.3, and D.4, respectively. Estimated remediation costs for this alternative are sensitive to a variation in the quantity of soil which must be excavated and transported to the off-site landfill. The distribution of subsurface soil samples collected during the RI was not sufficient to obtain an accurate estimate of the extent of contamination at the 1949 Pit or Landfill 1 (ABB-ES, 1993a). Consequently, the volume of contaminated soil could be significantly smaller, or larger, than that assumed (i.e., 5,450 cubic yards) in the cost estimate for this alternative.

**9.2.3.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 9-13.

### 9.2.4 Comparative Analysis of Alternatives

This subsection compares the relative advantages and disadvantages of the subsurface soil alternatives using the evaluation criteria. A comparative summary is provided in Table 9-14.

**9.2.4.1 Overall Protection of Human Health and the Environment.** Although Alternative PBG-SB1 potentially protects human health by restricting invasive activities in Landfill 1 and the 1949 Pit, no remedial activities would be implemented to reduce leachate generation and protect groundwater quality. Alternative PBG-SB2 not only includes restricting invasive activities in Landfill 1 and the 1949 Pit, but the caps would add a physical barrier between contaminated subsurface soil and potential receptors. However, the primary purpose of the caps would be to reduce leachate generation and protect groundwater quality. Consequently, Alternative PBG-SB2 has high potential to protect both human health and groundwater. Only Alternative PBG-SB3 is capable of providing complete protection of human health and groundwater by transferring contaminated soil to a more secure location (i.e., off-site landfill). Because the receiving off-site landfill would be equipped with a leachate collection system and, upon landfill closure, a cap, Alternative PBG-SB3 provides a slightly higher degree of long-term groundwater protection than Alternative PBG-SB2.

**9.2.4.2 Compliance with ARARs.** Chemical-specific ARARs have not been promulgated for the contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater are contained in the proposed Chapter NR 720 and are being applied to BAAP soil remediation. Because soil contaminants

would not be removed or destroyed, Alternatives PBG-SB1 and PBG-SB2 would not comply with pathway-specific numeric standards contained in the proposed Chapter NR 720. However, capping used in Alternative PBG-SB2 could be designed to achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of human health and groundwater. The performance standard would include eliminating the availability of contaminant concentrations which exceed numeric clean-up standards for protection of human health and preventing contaminant concentrations which exceed numeric clean-up standards for protection of groundwater from degrading groundwater quality. By removing contaminated soil from Landfill 1 and the 1949 Pit, only Alternative PBG-SB3 is capable of achieving the numeric clean-up standards for protection of human health and groundwater contained in the proposed Chapter NR 720. All the alternatives would be expected to meet location- and action-specific ARARs during and after remedial activities.

**9.2.4.3 Long-term Effectiveness and Permanence.** The long-term effectiveness and permanence of Alternative PBG-SB1 for protection of human health would be entirely dependent upon the implementation of plans to administer Landfill 1 and the 1949 Pit. While the caps would add a physical barrier between contaminated subsurface soil and potential receptors, and would be designed to protect groundwater, the long-term effectiveness and permanence of Alternative PBG-SB2 would also be dependent upon implementation of plans to administer and maintain Landfill 1 and the 1949 Pit after the caps have been constructed. Failure to adequately administer and maintain Landfill 1 and the 1949 Pit after implementation of Alternatives PBG-SB1 and PBG-SB2 could result in significant post-remediation exposure events such as construction-related invasive activities into contaminated soil. Invasive activities after implementation of Alternative PBG-SB2 could also compromise the integrity of the caps and cause leachate generation and associated degradation of groundwater quality. By comparison, Alternative PBG-SB3 would remove contaminated soil and the associated threat of groundwater degradation from Landfill 1 and the 1949 Pit. While Alternative PBG-SB3 would provide a high degree of long-term effectiveness and permanence at Landfill 1 and the 1949 Pit, responsibility for long-term protection of human health and groundwater would be transferred to the receiving landfill and would be dependent upon implementation of plans to administer and maintain that landfill.

**9.2.4.4 Reduction in Toxicity, Mobility, and Volume through Treatment.** Treatment is not directly identified as a component of any of the alternatives. However, caps associated with Alternative PBG-SB2 would limit natural mobilizing influences (i.e.,

infiltrating precipitation), thus reducing leachate generation. If TCLP criteria for PB in subsurface soil is exceeded, Alternative PBG-SB3 may include S/S treatment at the receiving off-site landfill. Potential mobility would be reduced by S/S but the volume of contaminated soil would increase by up to 50 percent.

**9.2.4.5 Short-term Effectiveness.** No adverse impacts to the community or the environment would be experienced during implementation of Alternatives PBG-SB1 or PBG-SB2. Only minor adverse impacts would be experienced during implementation of Alternative PBG-SB3, and those would only occur in the immediate vicinity of Landfill 1 and the 1949 Pit.

**9.2.4.6 Implementability.** No implementability concerns are associated with any of the alternatives.

**9.2.4.7 Cost.** Alternative PBG-SB1 has a low capital cost (i.e., $10,000) and a low present worth operation and maintenance cost (i.e., $108,000). Alternative PBG-SB3 has a high capital cost (i.e., $2,843,000) but no associated operation and maintenance cost. Alternative PBG-SB2 has a capital cost (i.e., $1,252,000) that is less than half that of Alternative PBG-SS3.

### 9.2.5 Selection of Preferred Alternative

Alternative PBG-SB2 (i.e., Capping) is the preferred alternative for subsurface soil remediation at the Propellant Burning Ground. Assuming institutional controls to restrict intrusive activities from the caps are properly implemented and the caps can achieve performance standards that meet the intent of the proposed Chapter NR 720, Alternative PBG-SB2 has a high potential for protecting human health and groundwater. Although Alternative PBG-SB3 is definitely capable of achieving numeric clean-up standards for protection of human health and groundwater contained in the proposed Chapter NR 720, the degree of overall protection of human health and the environment provided by Alternative PBG-SB3 is not expected to be significantly greater than that of Alternative PBG-SB2. Considering the small added benefit to human health and the environment, the high cost associated with Alternative PBG-SB3 would not be warranted.

## 9.3 Waste Pit Alternatives

The following waste pit remedial alternatives were retained for detailed analysis:

- Minimal Action (PBG-WP1)
- On-site Incineration and Capping (PBG-WP4)
- Composting and Capping (PBG-WP5)
- In Situ Vacuum Extraction, Composting and Capping (PBG-WP7)
- In Situ Treatment (PBG-WP8)
- On-Site Incineration (PBG-WP10)
- In Situ Vacuum Extraction, Soil Washing, and Composting (PBG-WP11)

Minimal Action was retained because it will serve as a baseline for the other waste pit alternatives. On-Site Incineration and Capping, and Composting and Capping are designed to protect human health and reduce leachate generation in the waste pits by: (1) excavating and treating severely contaminated soil, and (2) constructing caps over the waste pits. In Situ Vacuum Extraction, Composting, and Capping takes treatment one step further by removing VOCs (i.e., C6H6 and TRCLE) from the full depth of the contaminated soil zone prior to excavation of severely contaminated soil and cap construction. In Situ Treatment is designed to protect human health and eliminate leachate generation in the waste pits by either flushing contaminants out of the waste pit soils or chemically-biologically degrading the contaminants in situ. On-Site Incineration, and In Situ Vacuum Extraction, Soil Washing, and Composting, are designed to protect human health and eliminate leachate generation in the waste pits by removing the entire volume of contaminated soil from the waste pits and treating the soil. These remedial alternatives are described and evaluated in detail in the following subsections.

### 9.3.1 Alternative PBG-WP1: Minimal Action

This subsection describes the minimal action alternative, provides a cost estimate, and evaluates the alternative against the nine criteria.

**9.3.1.1 Description.** The minimal action alternative was developed to assess impacts on human health and the environment if no remedial actions are implemented. Components of this alternative are as follows:

- institutional controls
- educational programs, including public meetings and presentation
- monitoring program with 5-year site reviews

Key components are discussed in the following paragraphs.

Institutional Controls. Institutional controls in the form of deed or zoning restrictions would be implemented to prohibit use of groundwater within and around the site. At present, the Army has no plans to designate areas within BAAP for residential or public use. In the event the Army does decommission the facility and transfer it to the public, institutional controls in the form of deed and zoning restrictions would be implemented to restrict site use. The legal ramifications associated with instituting property deed restriction will need to be coordinated with appropriate Army officials, WDNR, and the City of Baraboo.

Educational Programs. This component includes public meetings and presentations to keep the public informed of the site status. Site status refers to both the general condition of the site and remaining contaminant levels.

Monitoring Program. Under CERCLA 121c, remedial action that results in contaminants remaining on site must be reviewed at least every five years. Data collected during the monitoring program would provide information for these reviews. The reviews would determine whether human health and the environment are being adequately protected. If appropriate, remedial action may be initiated.

The monitoring program would be implemented to evaluate the potential migration of contaminants from the Propellant Burning Ground Waste Pits to the underlying aquifer.

The groundwater monitoring program implemented would be a continuation of the ongoing monitoring program defined in the October 30, 1992 "Modification of Conditional Plan Approval of In-field Conditions Report" (WDNR, 1992) attached in Appendix D.1. The purpose of this BAAP-wide sampling and analysis program is to monitor contamination migration and assess future environmental impacts. A description of monitoring locations, analytical parameters, and monitoring frequency

pertinent to the Propellant Burning Ground are presented in conjunction with the Minimal Action Alternative (i.e., PBG-GW1) for groundwater. Minimal Action for groundwater is presented in Subsection 9.4.1.

**9.3.1.2 Cost Estimate.** For cost-estimating purposes, the following assumptions were made:

- $10,000 for institutional controls
- educational programs, $5,000 per year for 30 years

NOTE: Although groundwater monitoring and five-year site reviews are required components of this alternative, their costs are included in the groundwater remedial alternative estimates (see Subsection 9.4).

The cost estimate for this alternative is shown in Table 9-15.

**9.3.1.3 Alternative Evaluation.** The assessment of this alternative against the evaluation criteria is presented in Table 9-16.

### 9.3.2 Alternative PBG-WP4: On-site Incineration and Capping

This subsection describes the on-site incineration and capping alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the nine evaluation criteria.

**9.3.2.1 Description.** The on-site incineration and capping alternative consists of: (1) excavating waste pit soil to a depth of approximately 30 feet bgs in the center of WP-1 and approximately 20 feet below the bottom of WP-2 and WP-3; (2) incinerating the contaminated soil on site; and (3) capping each waste pit after backfilling. Figure 9-9 is a typical cross section of a backfilled and capped waste pit with respect to the extent of contamination. Key components of the alternative are:

- site preparation and mobilization
- contaminated soil delineation
- excavation, screening, and blending of contaminated soil
- incineration of contaminated soil
- transportation of secondary waste streams off site
- backfilling excavations
- cap construction

- post-closure maintenance
- institutional controls (see Subsection 9.3.1.1)
- groundwater monitoring (see Subsection 9.4.1.1)
- five-year site reviews (see Subsection 9.4.1.1)

Institutional controls, groundwater monitoring, and five-year site reviews for this alternative would be similar to those discussed in Subsections 9.3.1.1 and 9.4.1.1. However, institutional controls would have the added purpose of protecting the caps from invasive activities. Other key components are discussed in the following paragraphs. The alternative design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

Site Preparation and Mobilization. Stockpile areas for cap materials (i.e., clay, drainage sand, common borrow, and topsoil) would be established west of the 1949 Pit area. The proposed stockpile area is shown in Figure 9-10. The area would be large enough to provide sufficient volume for several days of cap construction in the event delivery from the sources is interrupted. A parking area for a mobile laboratory, construction-support trailers, and heavy equipment would also be located to the west of the 1949 Pit area and would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot (see Figure 9-10).

The incinerator would be positioned on a level grade to the southwest of the 1949 Pit area (see Figure 9-10). The incineration facility would require approximately 1 acre for stockpiling of untreated and treated soils and 2 acres for the incinerator, auxiliary equipment, and operations trailers. The site for the incineration facility would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot. Because the excavated soil is potentially a RCRA hazardous waste (i.e., potentially failing the TCLP test for 24DNT), the untreated soil stockpile area would be designed and constructed to meet regulatory requirements for temporary storage of hazardous waste. These requirements would include lining and berming the stockpile area to contain runoff from stockpiled soil.

A concrete decontamination pad would be constructed in the parking area (see Figure 9-10). The pad would be used to decontaminate heavy equipment used during excavation. The pad would be designed to collect the decontamination water in a sump, and to pump or gravity-drain the water into a collection tank.

Equipment mobilized to the site would include the incinerator, earth-moving equipment (i.e., cranes, backhoes, front-end loaders, and bulldozers), dumptrucks, a mobile laboratory, and construction-support trailers.

Contaminated Soil Delineation. The primary waste pit soil contaminant is 24DNT. The other waste pit soil contaminants (i.e., 26DNT, CPAH, C6H6, TRCLE, AS, CR, PB, SE, and ZN) are co-located with 24DNT. Consequently, soil requiring remediation would be delineated using predetermined concentrations of 24DNT for the lateral and vertical contamination boundaries. The preliminary lateral contamination boundary would be delineated using the field measurement detection limit for 24DNT in soil (i.e., 2 mg/kg) (Jenkins and Walsh, 1991) (see Figure 9-9). Additional samples would be collected beyond the preliminary lateral contamination boundary and analyzed in a certified laboratory to ensure the RGs for all the contaminants have been achieved. The vertical contamination boundary would be delineated by sampling through the center of the waste pits and using a 24DNT concentration of less than 10,000 mg/kg to mark the bottom of the excavation (see Figure 9-9). In WP-1, 24DNT concentrations fall below 10,000 mg/kg at approximately 30 feet bgs in the center of the former pit. For purposes of this evaluation, it is assumed that 24DNT concentrations in WP-2 and WP-3 fall below 10,000 mg/kg at approximately 20 feet below the bottom of the pits. The bottom of the excavations would be level between the lateral contamination boundaries (see Figure 9-9). Delineation would be conducted prior to excavation using a subsurface sampling device (e.g., split-spoons). A colorimetric-based method using a spectrophotometer would be used for field measurement of 24DNT (Jenkins and Walsh, 1991). The mobile laboratory would be equipped with the field measurement equipment.

Excavation, Blending, and Screening of Contaminated Soil. Contaminated soil would be excavated from the waste pits using backhoes and/or cranes equipped with clamshells. The excavations would either be shored with sheeting and bracing and/or sloped in accordance with Occupational Safety and Health Administration (OSHA) requirements (see Figure 9-9). Dumptrucks equipped with liners would transport the soil to the untreated soil stockpile area.

During excavation activities, an exclusion zone would be established that would encompass the site (see Figure 9-10). Excavation and handling equipment would operate within this zone and would not leave without first undergoing decontamination.

Safety considerations associated with incinerating explosives-contaminated waste require blending the soil to reduce the maximum concentration of DNTs to below 10,000 mg/kg (Cosmos, 1993). Soil blending would be conducted at the untreated soil stockpile area and could be accomplished with a backhoe.

Screening of sandy soil, such as that present in the waste pits, could be accomplished using a bar screen followed by a power screen (Leuser, Velazquez, and Cohen, 1989). Screened soil would be introduced into the feed hopper of the incinerator.

Incineration of Contaminated Soil. Because there is a greater number of mobile rotary kiln incinerators versus other types of mobile incinerators currently available for soil remediation, a mobile rotary kiln incinerator would likely be used during waste pit soil remediation. A rotary kiln incinerator owned by Roy F. Weston, Inc., identified as the "TIS-20", is used as an example for purposes of this evaluation. The TIS-20 was used to incinerate trinitrotoluene-contaminated soil at the Savanna Army Depot Activity and is capable of treating soil at a nominal feed rate of 20 tons per hour (Cosmos, 1993). A process flow schematic for the TIS-20 is shown in Figure 9-11. An estimated nine to 12 months would be required for trial burns and permitting the incinerator.

Blended and screened soil would be loaded into the feed hopper of the incinerator using a front-end loader. A conveyor and feed screws move the feed material into the kiln (operated at temperatures up to 2,200 degrees F). The kiln design provides for retention times of 15 to 90 minutes. Retention time is controlled by varying the kiln rotational speed and the feed rate to the system. Treated soil falls from the discharge end of the kiln to a conveyor where it is cooled by both water spray and heat transfer to a screw conveyor. A belt conveyor transfers the treated soil into watertight steel dumpsters. The steel dumpsters are transported to the treated soil stockpile and emptied.

The secondary combustion chamber (operated at temperatures up to 2,200 degrees F) is equipped with a primary burner and an auxiliary burner. The auxiliary burner is activated in the event the primary burner fails. Gases exiting the secondary combustion chamber are cooled with water in the quench chamber and further cooled in a heat recovery heat exchanger prior to passing through the fabric filter (i.e., baghouse). The TIS-20 is equipped with an optional caustic scrubber that is used if incinerated materials produce significant quantities of acid gas. The scrubber provides removal of acid gases by neutralization with sodium hydroxide, a basic

solution. Gases are discharged to the atmosphere through a fiberglass exhaust stack if the scrubber is used, or through a steel stack if the scrubber is not used.

All utilities associated with the TIS-20 are skid-mounted. Utilities include a compressor system, fresh water, and a wastewater filtration and carbon adsorption system (for treating water from the caustic scrubber).

Transportation of Secondary Waste Streams Off Site. Secondary waste streams that require off-site disposal include fly ash (from the baghouse) and decontamination water. The fly ash would require stabilization prior to disposal if it fails the TCLP analysis for metals.

Backfill Excavations. Following soil treatment, treated soil, stockpiled overburden and clean fill would be placed in the excavations and compacted to reduce settlement (see Figure 9-9).

Cap Construction. A ¼-acre multilayered cap would be installed over each of the backfilled waste pits. Figure 9-9 shows a typical cap construction cross section at one of the waste pits. The caps would be constructed of the following layers of material (from the bottom up):

- compacted clay layer
- 60-mil flexible membrane liner
- sand drainage layer
- filter fabric
- compacted common borrow layer
- topsoil layer

After an appropriate base grade has been established, a 2-foot layer of clay, compacted to achieve a hydraulic conductivity of $1x10^{-7}$ cm/sec or less, would be constructed over the graded area. Following placement of the clay layer, a 60-mil flexible membrane liner would be placed over the entire clay layer and anchored into the existing soil at the perimeter of the clay layer. A 1-foot layer of drainage sand would be placed over the flexible membrane liner. The permeability of the drainage layer would be $5x10^{-3}$ cm/sec or greater. Filter fabric would be placed over the drainage sand to prevent the migration of fines from the common borrow and topsoil layers into the drainage layer. A 2-foot layer of common borrow would be placed and compacted over the filter fabric. The 2-foot layer of common borrow, in conjunction with the 1-foot topsoil layer, would provide protection against frost

penetration. The topsoil layer would be fertilized and seeded to provide a good vegetative cover.

Each cap would taper on all sides with an average slope of 5:1 (see Figure 9-9).

Post-Closure Maintenance. Post-closure maintenance would include annual inspections and, if necessary, performing cap repair. Repairs would be required if the caps have been damaged by burrowing animals, vehicular traffic, or loss of vegetation. Cap vegetation would be mowed on an annual basis to prevent trees from taking root and damaging the caps.

**9.3.2.2 Cost Estimate and Sensitivity Analysis.** For cost-estimating purposes, the following assumptions were made:

- 2-acre stockpile area for cap materials
- 0.25-acre untreated (hazardous) soil stockpile area
- 0.75-acre treated soil stockpile area
- 0.5-acre parking area
- 2-acre incineration site
- one concrete decontamination pad
- 40 samples analyzed off site during contaminated soil delineation
- 1,250 cubic yards of contaminated soil per waste pit
- $3 million for incinerator mobilization/demobilization
- 6,000 tons of soil incinerated (includes floor of untreated soil area)
- $200 per ton for incineration
- 375 cubic yards (563 tons) of fly ash for off-site disposal
- 108-mile one-way trip to off-site landfill (Menomonee Falls, WI)
- $4.75 per loaded mile
- $142.50 per ton for fly ash treatment (S/S) and disposal
- 0.25-acre cap at each waste pit
- 8-hour annual visual inspection
- $10,000 for institutional controls

NOTE: Although groundwater monitoring and five-year site reviews are required components of this alternative, their costs are included in the groundwater remedial alternative estimates (see Subsection 9.4).

The cost estimate for this alternative is shown in Table 9-17. Cost, material usage, and vendor information are provided in Appendices D.2, D.3, and D.4, respectively.

Estimated remediation costs for this alternative are sensitive to a variation in the quantity of soil that must be excavated and incinerated. The distribution of waste pit soil samples collected during the RI was not sufficient to obtain an accurate estimate of the lateral and vertical extent of contamination in waste pit soil (ABB-ES, 1993a). Consequently, the volume of contaminated soil could be significantly smaller, or larger, than that assumed (i.e., 1,250 cubic yards per pit) in the cost estimate for this alternative.

**9.3.2.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 9-18.

### 9.3.3 Alternative PBG-WP5: Composting and Capping

This subsection describes the composting and capping alternative, provides a cost estimate for the alternative, and evaluates the alternative using the seven evaluation criteria.

**9.3.3.1 Description.** The composting and capping alternative consists of: (1) excavating waste pit soil to a depth of approximately 30 feet bgs in the center of WP-1 and approximately 20 feet below the bottom of WP-2 and WP-3; (2) composting the contaminated soil on site; and (3) capping each waste pit after backfilling with the finished compost. Figure 9-9 shows a typical cross section of the backfilled and capped pits with respect to the extent of contamination. Key components of the alternative are:

- treatability testing
- site preparation and mobilization
- contaminated soil delineation (see Subsection 9.3.2.1)
- excavation of contaminated soil
- screening, blending, and augmenting contaminated soil
- composting contaminated soil
- backfill excavations (see Subsection 9.3.2.1)
- cap construction (see Subsection 9.3.2.1)
- post-closure maintenance (see Subsection 9.3.2.1)
- institutional controls (see Subsection 9.3.1.1)
- groundwater monitoring (see Subsection 9.4.1.1)
- five-year site reviews (see Subsection 9.4.1.1)

Contaminated soil delineation, backfilling excavations, cap construction, and post-closure maintenance would be similar to those discussed in Subsection 9.3.2.1. Institutional controls, groundwater monitoring and five-year site reviews for this alternative would be similar to those discussed in Subsections 9.3.1.1 and 9.4.1.1. However, institutional controls would have the added purpose of protecting the caps from invasive activities. Other key components are discussed in the following paragraphs.

Composting can be implemented by three methods: (a) static pile, (b) windrows, and (c) mechanically agitated in-vessel. Based on field demonstrations conducted at another U.S. Army site (R.F. Weston, Inc., 1991 and R.F. Weston, Inc., 1993a), windrow composting has been selected for this site. Windrow composting consists of soil piles generally constructed in rows that are periodically turned to facilitate the microbial processes of composting. The conceptual process description of the composting system that follows addresses the system components and operations required to complete remediation. Figure 9-12 presents a schematic flow of operations for the composting system. The details included in the process description might be refined during remedial design, but the basic processing operations would remain the same.

Treatability Testing. The primary historical use for composting technology has been the treatment of municipal solid wastes, agricultural wastes, and wastewater treatment plant sludges. However, more recent interest has developed in its potential use for treatment of industrial wastes. The USAEC has conducted several pilot-scale composting studies to evaluate this technology for explosives-contaminated soils and sediments (Roy F. Weston, Inc., 1993b). Field demonstrations of composting explosives-contaminated (TNT, HMX, and RDX) and propellant-contaminated (NC) soils have been conducted at the Louisiana Army Ammunition Plant, BAAP, and the Umatilla Army Depot Activity (UMDA) and were successful in terms of reducing explosive concentrations through biotransformation. Initial TNT concentrations of as high as 17,872 mg/kg were reduced by greater than 99 percent (Roy F. Weston, Inc., 1988). Of the four explosives present in these experiments, TNT is the most rapidly transformed. Although composting of DNTs has not specifically been tested, data from the USAEC field demonstrations indicate that composting of DNT-contaminated soil should be successful. Literature on the subject of nitroaromatic degradation includes considerable information concerning degradation pathways and the relative biodegradability of TNT and DNT. In general, DNTs appear to degrade more quickly and completely than TNT. Degradation intermediates and their toxicities are

known as are the kinetics for various microorganisms (Suen, W.C. and J.C. Spain, 1993). While TNT biodegradation involves some potentially toxic and refractory intermediates, DNT biodegradation apparently proceeds to completion with little difficulty. Another product of the USAEC field demonstrations is a model that assists designers during bench-scale testing in the selection of composting parameters including amendments, soil-amendment ratios, and composting period (Brinton, W., 1994). Good correlation of the model results to the actual full-scale demonstration at UMDA were obtained.

Contaminated soil from the waste pits would undergo bench-scale testing to identify the best combination and proportions of available soil amendments using an adiabatic composter to evaluate the temperature profile and respiration rates of each compost mixture. Availability of potential soil amendments (e.g., sawdust, alfalfa, chicken manure, cow manure, and potato waste) in the vicinity of BAAP would be determined prior to testing. Once a "compost recipe" is selected, further testing would be conducted to assess the effect of different soil loading rates on composting performance. Using the composting model from bench-scale testing, a full-scale process for composting waste pit soil could be designed. The time required for bench-scale testing is estimated to be two months.

<u>Site Preparation and Mobilization</u>. Stockpile areas for cap materials (i.e., clay, drainage sand, common borrow, and topsoil) would be established west of the 1949 Pit area. The proposed stockpile area is shown in Figure 9-13. The area would be large enough to provide sufficient volume for several days of cap construction in the event delivery from the sources is interrupted. A parking area for a mobile laboratory, construction-support trailers, and heavy equipment would also be located to the west of the 1949 Pit area and would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot (see Figure 9-13).

The composting facility would be located southwest of the 1949 Pit area as shown in Figure 9-13. The contaminated soil would be stockpiled inside a temporary structure constructed on a bermed asphalt foundation pad. The stockpile structure would require approximately 0.25-acre, designed to stockpile about half of the total quantity of contaminated soil at one time. Adjacent to the stockpile structure, an asphalted and bermed area would be prepared for the soil-amendment mixing bins. South of the stockpile structure, four temporary structures for windrow composting would be constructed on a single asphalt foundation pad. Each structure would be 88 feet wide by 200 feet long. Structures by Sprung Structures, Inc., or equivalent, consisting of an external frame with plastic tensioned between the bars of the frame, would be

suitable for this application. With allowances for room to maneuver the mechanical windrow turner between the structures and around the perimeter, the total area required for the windrow composting structures is approximately 3 acres.

An area for treated compost would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot (see Figure 9-13). Adequate storage capacity would be provided to allow for flexibility in materials handling and to accommodate the analytical turnaround for performance verification sampling. The area required would be about 0.75-acre, assuming that the volume of the final compost is approximately twice the volume of the initial soil added (the amendment compacts during composting).

Based on the above, the total combined area required for the composting facility (including stockpile/parking areas) is approximately 7 acres.

<u>Excavation of Contaminated Soil</u>. Contaminated soil would be excavated from the waste pits using backhoes and/or cranes equipped with clamshells. The excavations would either be shored with sheeting and bracing and/or sloped in accordance with OSHA requirements (see Figure 9-9). Dumptrucks equipped with liners would transport the soil to the untreated soil stockpile area.

During excavation activities, an exclusion zone would be established that would encompass the site (see Figure 9-13). Excavation and handling equipment would operate within this zone and would not leave without first undergoing decontamination.

<u>Screening, Blending, and Augmenting Contaminated Soil</u>. Contaminated soil would be stockpiled in the untreated soil stockpile area. Large rocks and debris would be removed from the soil prior to composting to avoid undue stress or damage to the windrow turning equipment. For purposes of this FS, it is assumed that the entire volume of soil is passed through an appropriately sized vibrating screen. Because contaminated particulates might adhere to the surface of rocks, the rocks would be washed. The washwater would then be used to help maintain the desired compost moisture content. Therefore, treatment of the washwater would not be required. The screened soil would then be placed in the mixing area.

The mixing area would consist of four open-top, steel bins. Three of these bins would be used to mix soil and amendment. The fourth bin would be used to receive and temporarily store the organic amendment that would be delivered daily.

Several amendment compositions were evaluated during the field demonstration on explosives-contaminated soil at UMDA (R.F. Weston, Inc., 1991). Composting with either horse or cow manure was found to be more effective than chicken manure. Because cow manure is readily available in the BAAP area; and less expensive than horse manure, it is proposed that the amendment composition for this application include cow manure.

The field demonstration also indicated that the most effective soil loading volume, as a percentage of total compost volume, appears to be between 10 and 25 percent (R.F. Weston, Inc., 1991). Because a high soil loading inhibits self-heating, greater loading significantly reduces the degradation potential of explosives. For the development of costs and operating parameters in the FS, a soil loading volume of 20 percent is assumed. Soil loading has the single largest effect on the economics of the composting system. Changes in soil loading greatly influence the volume of amendment required, the size of the facility necessary to process the compost mixture, and the remediation period.

For every volume of screened soil placed into one of the mixing bins, four volumes of amendment would be added. The materials would be mixed in the bins using a front-end loader. Multiple mixing bins could allow for a completed batch to be removed from one bin while mixing is being done in a second, and screened soil is being added to a third. The mixed batches would be loaded into a dump truck and delivered to the windrow pad area. At the windrow pad area, a front-end loader would be used to form the mixture into a windrow.

For purposes of the FS, it is assumed that soil excavation and compost preparation would be performed five days per week, and that a total of 200 cubic yards of soil/amendment mix would be prepared each day.

Composting Contaminated Soil. The following conceptual description of windrow composting was based on the UMDA field demonstration and discussions with Roy F. Weston, Inc. (Lowe, W., 1993). The size and operating parameters of an actual facility would be modified based on the results of treatability tests.

The primary operating parameter is the assumption that a composting period of 45 days would be required to degrade explosives to acceptable levels. A longer composting period could be required from November through March because of low ambient air temperatures.

For purposes of costing this alternative, it was assumed that the four 88-foot by 200-foot temporary buildings would be erected on a single asphalt pad (Figure 9-13). Each building would be capable of enclosing two 150-foot-long windrows, with room available to maneuver a mechanical windrow machine. The benefits to covering the windrows include:

- reducing dispersion of material due to wind erosion;
- minimizing leachate by eliminating direct precipitation and storm water run-on; and
- better controlling temperature and moisture by reducing air exchange with the external atmosphere.

Once established, each windrow would need to be periodically turned by the windrow turning machine. Based on the UMDA field demonstration it is assumed that turning would be conducted once every other day. After a given windrow has composted for 45 days (seven weeks), it would be sampled to verify that RGs have been achieved. Four composite samples would be collected from each windrow for verification analysis. If RGs have been achieved, the compost would be loaded into a dump truck and stockpiled in the treated soil area. If the RGs have not been achieved, composting would continue.

Aeration for the compost matrix is provided by the windrow-turning machine, a self-propelled machine using a rotating drum with multiple short blades. As the machine moves along the windrow, the drum cuts into the windrow, macerating and fluffing the material, which allows air to be introduced into the compost matrix but also results in the loss of heat and water. The loss of heat and water can adversely affect the activity of the microbial populations. Enclosing the windrows within a covered structure would help reduce heat loss by maintaining a more uniform air temperature in the immediate vicinity of the material. To combat moisture loss, water would be added to the windrows as needed.

Utility requirements for the windrow system would include a continuous water supply for the compost. If supplies are insufficient and facility water is not available, a water tank truck could be brought on site. Water for the compost is not required to be potable. Total demand for process water is estimated to be from 5 to 8 gallons per minute. In addition, sufficient water pressure must be available to support the

fire protection system typically required for composting facilities. Electrical service of 220/440V, sufficient for normal equipment maintenance, is also required.

Six operating personnel would be required for windrow composting. This would include a maintenance supervisor, project supervisor, administrative assistant/clerk, and three equipment operators to operate the windrow machine, front-end loader, and dump truck. The operations schedule would typically consist of 8-hour shifts, five days per week.

**9.3.3.2 Cost Estimate and Sensitivity Analysis.** For cost-estimating purposes, the following assumptions were made:

- 2-acre stockpile area for cap materials
- 0.25-acre untreated (hazardous) soil stockpile area
- 0.25-acre soil/amendment mixing area
- 3-acre asphalt pad for composting area
- four leased temporary structures, each 88 feet by 200 feet
- 0.75-acre treated soil stockpile area
- 0.5-acre parking area
- one concrete decontamination pad
- composting treatability testing will cost $30,000
- 40 samples analyzed off site during contaminated soil delineation
- 1,250 cubic yards of contaminated soil per waste pit
- 6,000 tons of soil composted (includes floor of untreated soil area)
- $50 per ton for amendment (cow manure, straw, alfalfa, and vegetable wastes)

- soil would be 20 percent of total soil-amendment mixture
- composting period is 45 days
- 0.25-acre cap at each waste pit
- 8-hour annual visual inspection
- $10,000 for institutional controls

NOTE: Although groundwater monitoring and five-year site reviews are required components of this alternative, their costs are included in the groundwater remedial alternative estimates (see Subsection 9.4).

The cost estimate for this alternative is shown in Table 9-19. Cost, material usage, and vendor information are provided in Appendices D.2, D.3, and D.4, respectively. Estimated remediation costs for this alternative are sensitive to a variation in the quantity of soil which must be excavated and composted. The distribution of waste pit soil samples collected during the RI was not sufficient to obtain an accurate estimate of the lateral and vertical extent of contamination in waste pit soil (ABB-ES, 1993a). Consequently, the volume of contaminated soil could be significantly smaller, or larger, than that assumed (i.e,. 1,250 cubic yards per pit) in the cost estimate for this alternative.

**9.3.3.3 Remedial Alternative Evaluation**. The assessment of this alternative using the evaluation criteria is presented in Table 9-20.

### 9.3.4 Alternative PBG-WP7: In Situ Vacuum Extraction, Composting, and Capping

This subsection describes the in situ vacuum extraction, composting, and capping alternative, provides a cost estimate for the alternative, and evaluates the alternative using the seven evaluation criteria.

**9.3.4.1 Description.** The in situ vacuum extraction, composting, and capping alternative consists of: (1) filling Waste Pit Nos. 2 and 3 with clay borrow; (2) installing and operating vacuum extraction wells in the filled waste pits to remediate VOCs (i.e., C6H6 and TRCLE) in the contaminated soil zone; (3) excavating waste pit soil (after completion of VOC remediation) to a depth of approximately 30 feet bgs; (4) composting the contaminated soil on site; and (5) capping each waste pit

after backfilling with the finished compost. Figure 9-9 shows a typical cross section of the backfilled and capped pits with respect to the extent of contamination. Key components of the alternative are:

- treatability testing
- contaminated soil delineation (see Subsection 9.3.2.1)
- in situ vacuum extraction system construction
- in situ vacuum extraction system operation
- site preparation and mobilization (see Subsection 9.3.3.1)
- excavation of contaminated soil (see Subsection 9.3.3.1)
- screening, blending, and augmenting contaminated soil (see Subsection 9.3.3.1)
- composting contaminated soil (see Subsection 9.3.3.1)
- backfill excavations (see Subsection 9.3.2.1)
- cap construction (see Subsection 9.3.2.1)
- post-closure maintenance (see Subsection 9.3.2.1)
- institutional controls (see Subsection 9.3.1.1)
- groundwater monitoring (see Subsection 9.4.1.1)
- five-year site reviews (see Subsection 9.4.1.1)

Contaminated soil delineation, backfilling excavations, cap construction, and post-closure maintenance would be similar to those discussed in Subsection 9.3.2.1. Site preparation and mobilization, excavation of contaminated soil, screening/blending/augmenting contaminated soil, and composting contaminated soil would be similar to those discussed in Subsection 9.3.3.1. Institutional controls, groundwater monitoring, and five-year site reviews for this alternative would be

similar to those discussed in Subsections 9.3.1.1 and 9.4.1.1. However, institutional controls would have the added purpose of protecting the caps from invasive activities. Other key components are discussed in the following paragraphs. The alternative design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

Treatability Testing. Pilot testing in the subsurface soils below the waste pits would be necessary in order to design an in situ vacuum extraction system. The pilot tests would determine: (1) the radius of influence of an extraction well relative to vacuums measured in the subsurface; (2) intrinsic permeability of the soil; (3) vacuum levels and flow rates that could potentially be achieved during full-scale operation; (4) soil vapor concentrations before, during, and after the pilot test; and (5) vapor concentrations in the extracted gases which would determine the most appropriate treatment approach for the blower effluent. The pilot test could include installation of one vacuum extraction well in the center of Waste Pit No.1 (currently filled) and three monitoring probe locations at discrete distances from the extraction well.

The extraction well would be screened from approximately 15 feet to 100 feet bgs. Inflatable packers could be used in the extraction well during the pilot test to isolate zones of contamination in different soil strata. The blower attached to the extraction well would be capable of extracting 100 standard cubic feet per minute (scfm). Off-gases from the extraction well could be treated by passing them through activated carbon drums.

Each monitoring probe location could contain multiple probes positioned at different depths to determine the variation in air flow as a function of depth and differing soil strata. Probes located at different depths in the same well would be separated from each other by a bentonite or grout seal.

The pilot test would continue until at least one pore volume of vapor from the contaminated soil zone has been extracted, which is expected to take approximately 48 hours. Contaminant concentrations and/or vacuum would be measured at various locations in the monitoring, vapor extraction, and treatment systems during the test. Predictive models could be used to scale-up and design a full size system. The time required for treatability testing, including well construction, testing, and data interpretation, is estimated to be one month.

The primary historical use for composting technology has been the treatment of municipal solid wastes, agricultural wastes, and wastewater treatment plant sludges. However, more recent interest has developed in its potential use for treatment of industrial wastes. The USAEC has conducted several pilot-scale composting studies to evaluate this technology for explosives-contaminated soils and sediments (Roy F. Weston, Inc., 1993b). Field demonstrations of composting explosives-contaminated (TNT, HMX, and RDX) and propellant-contaminated (NC) soils have been conducted at the Louisiana Army Ammunition Plant, BAAP, and the Umatilla Army Depot Activity (UMDA) and were successful in terms of reducing explosive concentrations through biotransformation. Initial TNT concentrations of as high as 17,872 mg/kg were reduced by greater than 99 percent (Roy F. Weston, Inc., 1988). Of the four explosives present in these experiments, TNT is the most rapidly transformed. Although composting of DNTs has not specifically been tested, data from the USAEC field demonstrations indicate that composting of DNT-contaminated soil should be successful. Literature on the subject of nitroaromatic degradation includes considerable information concerning degradation pathways and the relative biodegradability of TNT and DNT. In general, DNTs appear to degrade more quickly and completely than TNT. Degradation intermediates and their toxicities are known as the kinetics for various microorganisms (Suen, W.C. and J.C. Spain, 1993). While TNT biodegradation involves some potentially toxic and refractory intermediates, DNT biodegradation apparently proceeds to completion with little difficulty. Another product of the USAEC field demonstrations is a model that assists designers during bench-scale testing in the selection of composting parameters including amendments, soil-amendment ratios, and composting period (Brinton, W., 1994). Good correlation of the model results to the actual full-scale demonstration at UMDA were obtained.

Contaminated soil from the waste pits would undergo bench-scale testing to identify the best combination and proportions of available soil amendments using an adiabatic composter to evaluate the temperature profile and respiration rates of each compost mixture. Availability of potential soil amendments (e.g., sawdust, alfalfa, chicken manure, cow manure, and potato waste) in the vicinity of BAAP would be determined prior to testing. Once a "compost recipe" is selected, further testing would be conducted to assess the effect of different soil loading rates on composting performance. Using the composting model from bench-scale testing, a full-scale process for composting waste pit soil could be designed. The time required for bench-scale testing is estimated to be two months.

In Situ Vacuum Extraction System Construction. Preliminary design indicates that one extraction well would be installed directly in the center of each waste pit (Figure 9-14). Waste Pit Nos. 2 and 3 would have to be filled (preferably with a clay borrow) prior to well installation. All of the wells would be screened from approximately 15 feet to 100 feet bgs. Well material would consist of 4-inch diameter PVC pipe, slotted in the screened interval, with gravel packing around the screens. Bentonite/grout seals would be placed above the screens to prevent vapor flow from short-circuiting the soil column.

All the extraction wells would be connected to a 300 cfm blower by 3-inch diameter PVC pipe. The blower would be part of a skid-mounted assembly which would also include the blower motor, moisture trap, air dilution valve, sample port, and vacuum, temperature, and pressure gauges (see Figure 9-14). The moisture trap would designed to remove liquid from the vapor stream and would be located upstream of the blower. The blower motor would operate on BAAP-supplied 3-phase electrical power. The discharge pipe for each blower would be connected to two 2,000-lb activated carbon adsorbers (see Figure 9-14). The carbon adsorbers would be connected to each other in a series configuration. A sample port would be located between the adsorbers. Treated emissions from the carbon adsorbers would be vented to the atmosphere.

Three vadose zone monitoring wells would be established at each waste pit (see Figure 9-14). For purposes of the FS, each monitoring well would include three discrete zones containing probes for sampling soil vapor and measuring temperature. The zones would be separated from each other by a bentonite/grout seal.

In Situ Vacuum Extraction System Operation. The vacuum extraction system would operate on a continuous basis until the RGs for VOCs (i.e., C6H6 and TRCLE) have been attained. Operation would consist of pulling a vacuum on the extraction wells and the surrounding soil column with the blower, reducing the relative humidity of the resultant vapor stream with the moisture trap, and discharging the dehumidified vapor stream through the activated carbon adsorbers and into the atmosphere. Routine maintenance would include draining the liquid collected in the moisture trap into a storage vessel and transporting the liquid to the IRM facility for treatment. Because 4,000 lbs of activated carbon is expected to be sufficient capacity for the duration of vacuum extraction activities, carbon replacement is not anticipated.

Daily monitoring of the vacuum extraction system would consist of checking temperature and vacuum in the vapor streams exiting each extraction well, checking

the liquid level in the moisture trap, and checking the temperature and pressure of the vapor stream entering the activated carbon adsorbers. Weekly monitoring would consist of collecting vapor samples from the monitoring wells and from the vacuum extraction system. Based on analysis of the samples, system operating parameters can be modified (e.g., increasing/decreasing vapor flow) and the progress of VOC remediation can be evaluated. For purposes of the FS, VOC remediation is assumed to require six months to complete.

**9.3.4.2 Cost Estimate and Sensitivity Analysis.** For cost-estimating purposes, the following assumptions were made:

- one vacuum extraction well per waste pit
- vacuum extraction and treatment systems are rented
- 4,000 lbs of activated carbon required to treat VOCs
- 2-acre stockpile area for cap materials
- 0.25-acre untreated (hazardous) soil stockpile area
- 0.25-acre soil/amendment mixing area
- 3-acre asphalt pad for composting area
- four leased temporary structures, each 88 feet by 200 feet
- 0.75-acre treated soil stockpile area
- 0.5-acre parking area
- one concrete decontamination pad
- 40 samples analyzed off site during contaminated soil delineation
- in situ vacuum extraction treatability testing will cost $45,000
- composting treatability testing will cost $30,000

- 1,250 cubic yards of contaminated soil per waste pit
- 6,000 tons of soil composted (includes floor of untreated soil area)
- $50 per ton for amendment (cow manure, straw, alfalfa, and vegetable wastes)
- soil would be 20 percent of total soil-amendment mixture
- composting period is 45 days
- 0.25-acre cap at each waste pit
- 8-hour annual visual inspection
- $10,000 for institutional controls

NOTE: Although groundwater monitoring and five-year site reviews are required components of this alternative, their costs are included in the groundwater remedial alternative estimates (see Subsection 9.4).

The cost estimate for this alternative is shown in Table 9-21. Cost, material usage, and vendor information are provided in Appendices D.2, D.3, and D.4, respectively. Estimated remediation costs for this alternative are sensitive to a variation in the quantity of soil which must be excavated and composted. The distribution of waste pit soil samples collected during the RI was not sufficient to obtain an accurate estimate of the lateral and vertical extent of contamination in waste pit soil (ABB-ES, 1993a). Consequently, the volume of contaminated soil could be significantly smaller, or larger, than that assumed (i.e., 1,250 cubic yards per pit) in the cost estimate for this alternative.

**9.3.4.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 9-22.

### 9.3.5 Alternative PBG-WP8: In Situ Treatment

This subsection describes the in situ treatment alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the nine evaluation criteria.

**9.3.5.1 Description.** The in situ treatment alternative consists of constructing a slurry and/or grout barrier system completely enclosing contaminated soil around and beneath each of the three waste pits and treating the soil with one of the two treatment technologies evaluated during treatability studies. If soil flushing is the selected technology it would consist of: (1) constructing buried pipelines to and from the waste pits; (2) constructing an infiltration gallery at each of the waste pits; (3) extracting groundwater from BAAP Well No. 5; (4) mixing flushing additives into the extracted groundwater (if needed); (5) pumping the flushing solution to the infiltration basins; (6) extracting the solution after it infiltrates to the bottom of the barrier system; and (7) pumping the flushing solution to the IRM facility for treatment of solubilized/suspended soil contaminants. Figure 9-15 is a typical cross section of a waste pit with barrier and in situ soil flushing systems in place. If chemical-biological is the selected technology it would consist of the following four treatment phases which each include deep soil mixing equipment to inject and mix chemicals/nutrients into waste pit soil: (1) addition of 0.1 percent iron sulfate solution; (2) addition of 1 to 2 percent hydrogen peroxide solution; (3) addition of an acid or base for pH adjustment; and (4) addition of nutrients. Figure 9-16 is a typical cross section of a waste pit with barrier and deep soil mixing equipment in operation. Key components of the alternative (including soil flushing and chemical-biological components) are:

- treatability testing of barrier design, soil flushing, and chemical-biological
- mobilization and site preparation
- contaminated soil delineation
- barrier system construction

Soil Flushing

- pipeline construction
- infiltration gallery construction
- water table extraction well installation
- in situ soil flushing system operation
- confirmatory sampling

Chemical-Biological

- addition of iron sulfate
- addition of hydrogen peroxide

- pH adjustment
- addition of nutrients
- confirmatory sampling

Key components are discussed in the following paragraphs. The alternative design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

Treatability Testing of Barrier Design, Soil Flushing, and Chemical-Biological. Although barrier system integrity may not be a long-term requirement for this alternative, various tests should be conducted to determine the permeability characteristics and compatibility of barrier system materials with waste pit contaminants and potential treatment chemicals. Initial testing would include evaluating the strength and permeability of various mixes of native soils in combination with cement, water, bentonite, or grout. Tests conducted with waste pit contaminants and chemical solutions would evaluate the potential for the contaminants and treatment chemicals to degrade the barrier system and increase its permeability. Tests would be conducted, if applicable, with native soils to determine the potential for barrier material piping into native soils downgradient of the barrier system. The source of water which would be used for mixing the barrier materials would also be tested to confirm that the barrier would cure properly, with no competing reactions which would increase barrier system permeability.

Because the likely method for barrier system construction would involve overlapping columns of soil-cement, soil-bentonite, or grout, full-scale pilot tests should also be conducted to evaluate the overall permeability of the barrier system. Pilot tests could include construction of a number of overlapping columns to the design depth. Continuity and permeability of the overlapping columns could be checked by several different methods, including:

- bulk samples collected prior to curing to provide samples for permeability testing;

- core samples collected after curing at column interconnect points to verify continuity and provide samples for permeability testing;

- placement of vertical pipes at preestablished locations in the overlapping columns through which transmitters and receivers are

lowered and used to check barrier continuity via propagation of sonic waves; and

- direct examination of the test columns by excavation around the columns.

Treatability testing of soil flushing and chemical-biological would occur simultaneously. Extensive bench-scale testing may be required to select materials and determine operating parameters for both technologies. Extensive pilot-scale testing may also be required to establish the effectiveness of soil flushing and chemical-biological in the chemical (e.g., multiple contaminants at existing concentrations) and physical (e.g., geology and hydrogeology) environment of the waste pits. Pilot-scale tests should include all of the design elements (i.e., barrier system and treatment technology components) of in situ soil treatment so that: (1) a system capable of attaining the RGs within a reasonable period of time can be designed; and (2) it can be demonstrated that the system would contain contamination and prevent its migration into the aquifer. The time required for treatability testing is estimated to be one year.

<u>Site Preparation and Mobilization</u>. A staging area for construction materials would be established to the west of the 1949 Pit (Figure 9-17). A portion of the staging area would be covered to protect barrier system materials (e.g., bentonite and cement) from inclement weather. A parking area for heavy equipment, a mobile laboratory, and construction-support trailers would be located adjacent to the staging area and prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot (see Figure 9-17).

Equipment mobilized to the site would include earth-moving equipment (e.g., backhoes, front-end loaders, and bulldozers), specialized barrier system construction equipment, drill rig(s), cranes, dump trucks, a mobile laboratory, and construction-support trailers.

<u>Contaminated Soil Delineation</u>. Delineation would be conducted prior to construction using a subsurface sampling device (e.g., split-spoons). The primary waste pit soil contaminant is 24DNT. The other waste pit soil contaminants (i.e., 26DNT, CPAH, TRCLE, AS, CR, PB, SE, and ZN) are co-located with 24DNT. Consequently, soil requiring remediation would be initially delineated using a field measurement detection limit for 24DNT (e.g., 2 mg/kg) as the preliminary lateral

and vertical contamination boundaries. A colorimetric method using a spectrophotometer could be used for field measurement of 24DNT (Jenkins and Walsh, 1991). Additional samples would be collected beyond the preliminary contamination boundaries and analyzed off site in a certified laboratory to ensure the RGs for all the contaminants have been achieved. The vertical contamination boundary is expected to be approximately 100 feet bgs. The mobile laboratory would be equipped with the field screening equipment.

Barrier System Construction. A barrier system would be constructed that would completely enclose the contaminated soil beneath each of the three waste pits. Two different barrier system designs are discussed in the following paragraphs; each with their respective advantages and disadvantages.

The first design, or "can" design, would include construction of a barrier floor at approximately 100 feet bgs using deep soil mixing equipment or jet grouting equipment (Figures 9-15 and 9-16). The barrier floor constructed with the deep soil mixing equipment would consist of overlapping columns, approximately 15 feet long, with a grout content that is 25 percent of the soil-grout mixture (Herceg, W., 1994). The grout ingredients would include cement, fly ash, and approximately 1.5 percent activated carbon. The barrier floor constructed with jet grouting equipment would consist of overlapping columns, approximately 5 feet long, that are a cement grout mixture (LaRose, R., 1994). Jet grouting generally consists of injecting a grout mixture, under high pressure, through special nozzles located at the bottom of a string of "rods" used to drill down to a given depth and to deliver the grout. Jet grouting can produce a barrier that is a soil-grout mixture or that is composed of only grout. The barrier walls in the can design would be keyed into the barrier floor and would be constructed using deep soil mixing equipment. The walls would be circular, approximately 110 feet in diameter, and would consist of overlapping columns of cement/fly ash, sodium bentonite, or a combination of several reagents; depending on the outcome of treatability studies. Several contractors, including S.M.W. Seiko, Inc., of Redwood City, California, have deep soil mixing equipment. The method used by S.M.W. Seiko is explained here as an example of barrier wall installation.

S.M.W. Seiko uses their patented Soil-Cement Mixed-in-Place Wall (S.M.W.) method to construct slurry walls up to a 200-foot depth. This method uses multiaxis augers and mixing paddles to construct overlapping soil-cement columns. The overlapping augers break up the soil. Cement grout is pumped into the boring through the auger shafts. The grout is mixed with the soil in situ by the auger flights and mixing paddles. Each three-column segment is overlapped with the subsequent segment.

The result is a continuous wall, with permeability ranging from $1 \times 10^{-6}$ to $1 \times 10^{-7}$ cm/sec (Taki and Yang, 1989). Figure 9-18 is a conceptual diagram of this type of structure.

The advantages of the can design include constructability. Civil projects which have included excavation of watertight vertical shafts to below the groundwater table have utilized designs which are similar to the can design. Several contractors have the capability to design and construct this type of barrier system. The disadvantages of the can design include invasive activities through the contaminated soil zone during construction of the barrier floor. These invasive activities would increase the potential for significant worker exposure to waste pit contaminants. Additionally, the Army considers soil with explosives concentrations greater than 10 percent to be a reactive hazard. The maximum detected 24DNT concentration in waste pit soil is 28 percent. Consequently, special precautions may have to be taken during drilling and grouting operations.

The second design, or "cone" design, would include construction of an upside-down barrier cone using jet grouting equipment (Figure 9-19) (Pearlman, S.L., 1994). The cone would consist of overlapping grout columns which are installed at a 45 degree angle. The grouted columns would begin at approximately 80 feet bgs and converge to a point at approximately 135 feet bgs (see Figure 9-19). From ground surface to 80 feet bgs the holes would remain ungrouted. The barrier walls in the cone design would be keyed into the outside edge of the cones and would be installed using deep soil mixing equipment. The barrier walls would be circular and would be approximately 110 feet in diameter (see Figure 9-19). A description of deep soil mixing technology is provided above.

The advantages of the cone design include being able to avoid drilling through the contaminated soil zone and, consequently, minimize the potential for worker exposure to waste pit contaminants. Concerns associated with drilling through soil with explosives concentrations greater than 10 percent are also avoided. Not only are health and safety concerns avoided but the shape of the cones would provide a low point where leachate would collect and be easily extracted for treatment. The disadvantages of the cone design include questionable constructability and potentially high cost. Apparently, this type of barrier system design has not been attempted before and the strict tolerances required to achieve an impermeable barrier may be unattainable. In order to be certain that the cone design results in an impermeable barrier, it may be necessary to construct as many as three concentric overlapping

cones. Construction of three concentric cones would probably result in unacceptably high cost.

Although there are disadvantages to the can design, it does offer the one advantage (i.e., constructability) that could be crucial to the effectiveness of the alternative. Consequently, for conceptual design and cost-estimating purposes, barrier system construction would be accomplished using the can design (LaRose, R., 1994). Jet grouting equipment would be used to construct a soil-cement grout floor that is approximately 5 feet thick and deep soil mixing equipment would be used to construct a soil-sodium bentonite grout wall that is approximately 3 feet thick. All grout would be supplied by an on-site automatic grout production and delivery plant.

Quality control during construction of the barrier system would include permeability and strength testing of the soil-grout mixtures used during jet grouting and deep soil mixing. Bulk samples and core samples would be collected from the in-place soil-grout columns prior to curing and after curing, respectively, and tested for permeability and unconfined compressive strength. In situ permeability testing could be conducted by: (1) filling core holes with clean water; (2) allowing the soil-grout column to saturate and achieve steady state drawdown; (3) inserting inflatable packers; (4) applying a measured head of water to the corehole after packer inflation; (5) measuring the drawdown over a period of time; and (6) calculating the permeability based upon drawdown and time. In addition to permeability and strength testing, water and grout ratios, grout "take," and installation depths would be monitored and recorded during construction.

The following paragraphs refer to components of soil flushing and would be implemented if soil flushing is the selected in situ treatment technology.

<u>Pipeline Construction</u>. A buried 4-inch diameter pipeline would be constructed from BAAP Well No. 5 to the waste pits (see Figure 9-17). Buried branch lines from the pipeline would penetrate the barrier wall at each of the waste pits and connect to an infiltration gallery. A manually or remotely operated valve would be installed in each branch line immediately outside the barrier enclosure to control flushing solution flow into the infiltration gallery (see Figure 9-17).

Buried branch lines and a 4-inch diameter pipeline would be constructed from the waste pits to the existing IRM facility source control well influent pipe (see Figure 9-17). If this alternative was implemented, the use of the existing influent

pipe would be converted to transport of influent from the soil flushing system to the IRM facility.

Infiltration Gallery Construction. An infiltration gallery would be constructed within the confines of the barrier system at each of the waste pits. The infiltration gallery would consist of perforated pipe buried in a 8-foot thick drainage sand layer (see Figure 9-17). The perforated pipe would be designed to evenly distribute the flushing solution over the area encompassed by the barrier system. Prior to infiltration gallery construction, WP-2 and WP-3 would be filled with granular soil (i.e., sand or gravel).

Water Table Extraction Well Installation. An 8-inch diameter extraction well, screened at the groundwater table, would be installed within the confines of the barrier system at each of the waste pits (see Figure 9-15). A submersible pump in each of the extraction wells would pump flushing solution with entrained soil contaminants to the IRM facility. The pumps would be rated to pump a maximum of 275 gpm at a total dynamic head (TDH) of 400 feet. Water level controllers for each of the barrier systems would be used to start and stop the pumps. The probes used in conjunction with the controllers could be set in piezometers located inside the barrier systems.

In Situ Soil Flushing System Operation. During operation of the in situ soil flushing system, 250 gpm of flushing solution would be pumped from BAAP Well No. 5 to the infiltration galleries. The discharge of flushing solution to the infiltration galleries could occur either continuously or intermittently, depending upon the optimal flushing process as determined during treatability studies. If discharge to each infiltration gallery occurred intermittently, flushing solution flow could be rotated at a regular interval among the three infiltration galleries so that flushing solution pumping and treatment would be constant.

Flushing solution would be withdrawn from the groundwater table via the extraction wells (see Figure 9-15). Because the flow capacity of the influent pipe to the IRM facility is limited, a maximum combined flow of 275 gpm would be pumped from the extraction wells. The flow from each extraction well would be sufficient to capture all of the flushing solution after it infiltrates to the groundwater table.

The flushing solution pumped from the extraction wells would be transported to the IRM facility for removal of waste pit soil contaminants and flushing solution additives

(if used). Only clean water would be discharged to the existing effluent pipe and the Wisconsin River.

Prior to estimating the length of time and cost required for attaining RGs in waste pit soils, a number of assumptions were made concerning the mass of contaminants present in waste pit soils and the rate at which they would leach out of the soils (see Appendix D.3). To obtain a more accurate estimate for cleanup time and cost, treatability studies would be necessary to determine the actual contaminant leaching rate and a contaminated soil delineation would be necessary to better estimate the mass of contaminants present in the waste pit soils.

Extrapolating from data provided in the RI Report, an estimated 96,900 lbs of DNTs are present in soils at each waste pit (see Appendix D.3) (ABB-ES, 1993a). This assumes a volume of soil 50 feet in diameter and 90 feet deep is contaminated with an average DNT concentration of 5,000 mg/kg. Assuming 250 gpm of water is pumped through the infiltration gallery at each waste pit and assuming 10 percent of 24DNT solubility (i.e., 24 mg/L) is reached as the water infiltrates the waste pit soils, approximately 76 lbs of DNTs would be removed from waste pit soils each day. At a removal rate of 76 lbs per day, all of the DNTs (i.e., 96,900 lbs) would be removed after approximately 1,300 days of flushing. It is possible that flushing additives would accelerate the DNT removal rate.

Based on a DNT removal rate from waste pit soils of 76 lbs per day, it is logical that a high DNT loading rate on activated carbon in the IRM facility carbon adsorption system would occur. Consequently, it is assumed that spent carbon would be replaced every six weeks, or approximately 9 rebeds per year. For a description of IRM facility operation, see Subsection 9.4.2.1.

Confirmatory Sampling. Confirmatory sampling would be conducted when the concentrations of contaminants in the IRM facility influent reach predetermined levels. Samples would be collected from borings installed through the thickness of the treated soil zone. If the RGs for waste pit soils have been attained, in situ soil flushing would be discontinued and the site demobilized. Otherwise, flushing would continue until boring samples indicate that the RGs have been attained.

The following paragraphs refer to components of chemical-biological and would be implemented if chemical-biological is the selected in situ treatment technology. Chemical-biological, as described in this subsection, is a technology that has been developed through the joint efforts of the Institute of Gas Technology (IGT) and

Millgard Environmental Corporation (MEC). IGT would be responsible for designing the chemical-biological treatment process while MEC would use their deep soil mixing "MecTool®" to deliver the treatment chemicals to the waste pit soil (see Figure 9-16) (IGT, 1994).

Addition of Iron Sulfate. The MecTool® would be used in the first phase to deliver a 0.1 percent iron sulfate solution to waste pit soil. The MecTool® is designed to vertically mix contaminated soil over the diameter of a treatment column while injecting treatment fluids into the soil. The treatment columns are overlapping to ensure complete treatment of the entire contaminated soil volume. The treatment fluids are delivered to high-pressure injection ports located on the mixing blade by pumping the fluids through the MecTool® hollow-stem kelly bar (see Figure 9-16). The design ratio of treatment fluid to soil is monitored as the mixing blade progresses downward through the soil column. In the event soil conditions change and affect the rate of mixing tool travel, the treatment fluid delivery rate can be modified to maintain the design ratio. VOCs which are mobilized during soil mixing and migrate toward ground surface would be contained by the use of a surface foaming agent or a grout layer. The MecTool® is also equipped with a containment shroud which is designed to capture fugitive emissions at the surface of the treatment column and direct them through an air treatment system prior to discharge to the atmosphere (see Figure 9-16).

Iron sulfate would be injected into waste pit soil in preparation for hydrogen peroxide addition, which would occur in the next phase of treatment. Iron sulfate would provide the catalyst needed to rapidly decompose the hydrogen peroxide and initiate chemical degradation. Combining iron with hydrogen peroxide produces what is known as Fenton's reagent. A decomposition product of Fenton's reagent is the hydroxyl radical, which is a very powerful oxidant.

Addition of Hydrogen Peroxide. The MecTool® would be used in the second phase to deliver 1 to 2 percent hydrogen peroxide solution to waste pit soil. The hydrogen peroxide would react with the iron sulfate delivered in the first phase to produce the hydroxyl radical discussed above. The hydroxyl radical would then begin to chemically oxidize the waste pit contaminants. Chemical oxidation would remove the contaminants from the soil matrix and would result in either their complete degradation to carbon dioxide and water or partially degrade them to compounds which are more biodegradable than the original contaminant. Although hydrogen peroxide is an effective bactericide in aqueous solution, it quickly reacts in the soil

matrix and does not act as a long-term disinfectant. Therefore, chemical oxidation does not negatively affect subsequent bioremediation.

pH Adjustment. Previous chemical-biological treatability studies on contaminants indicate that the pH of the soil can directly impact the rate of biodegradation. Consequently, the MecTool® would be used in the third phase to deliver a basic or acid solution, depending on the design requirements for optimal biodegradation. This would chemically condition the soil in preparation for the fourth phase.

Addition of Nutrients. The fourth and final phase would include the addition of nutrients to waste pit soil in order to stimulate the growth of indigenous populations of microorganisms. The MecTool® would be used to deliver a mix of nutrients that is designed to supplement existing soil nutrients. Contaminants that have been partially degraded during chemical oxidation in the second phase of treatment would be subjected to biological degradation as the microorganism populations grow. The products of biological degradation would ultimately be carbon dioxide and water. Subsurface soil sampling would be conducted during the final phase to confirm that the desired parameters (i.e., pH, temperature, oxygen, and nutrient concentrations) are suitable for biological degradation.

Confirmatory Sampling. Confirmatory sampling would be conducted when microbial activity in waste pit soil decreases to normal levels. Samples would be collected from borings installed through the thickness of the treated soil zone. If the RGs for waste pit soil have been attained, the site would be demobilized. Otherwise, an additional phase of chemical or biological treatment may be required.

**9.3.5.2 Cost Estimate and Sensitivity Analysis**. For cost-estimating purposes, the following assumptions were made:

- $528,000 (total) for treatability testing
- 1-acre staging area
- 40-foot by 80-foot temporary shelter
- 0.5-acre parking area
- 77 samples analyzed off site during contaminated soil delineation
- $7.928 million (total) for barrier system construction
- 96,900 lbs of DNTs present in soils at each waste pit
- one 8-inch diameter extraction well per waste pit
- 1,300 days of flushing per waste pit
- IRM system carbon replacement (20,000 lbs) every six weeks

Chemical-Biological

- MecTool® delivery of 0.1 percent iron sulfate solution
- MecTool® delivery of 1 to 2 percent hydrogen peroxide solution
- MecTool® delivery of pH adjusting solution
- MecTool® delivery of nutrients

The cost estimate for this alternative is shown in Table 9-23. Cost, material usage, and vendor information are provided in Appendices D.2, D.3, and D.4, respectively.

For soil flushing, estimated remediation costs for this alternative are sensitive to a variation in the mass of contaminants present in waste pit soils, the number of days that are required to achieve RGs, and the frequency of carbon replacement in the IRM Treatment Facility. The distribution of waste pit soil samples collected during the RI was not sufficient to obtain an accurate estimate of the mass of contaminants in the waste pits (ABB-ES, 1993a). The mass of contaminants could be significantly smaller, or larger, than that assumed (i.e., 96,900 lbs DNTs per waste pit) in the cost estimate for this alternative. Mass of contaminants, in conjunction with contaminant flushing rate, would determine the number of days required for waste pit remediation. The contaminant flushing rate for DNTs was assumed to be 24 mg of DNTs per liter of flushing solution infiltrating the waste pits. At a flushing solution flow of 250 gpm (approximately 1,000 liters per minute), 1,300 days is the estimated time of remediation at each waste pit. A variation from the assumed contaminant mass and flushing rate would result in a significantly shorter, or longer, cleanup time than that assumed (i.e., 1,300 days per waste pit) in the cost estimate for this alternative. The frequency of carbon replacement in the IRM facility would be a function of contaminant loading on the carbon during in situ soil flushing system operation. Information concerning contaminant concentrations in the influent flushing solution, and the resultant carbon usage rate, is not available. The actual frequency of carbon replacement could vary significantly from that assumed (i.e., 20,000 lbs every six weeks).

For chemical-biological, estimated remediation costs for this alternative are sensitive to variations in the number of treatment phases and the amount of chemicals used in each phase. Assuming that 852 working shifts using the MecTool® delivery system are required to complete four phases of chemical-biological treatment, each additional phase of treatment, if required, would require another 213 working shifts. Because each working shift has an estimated average cost of $13,930, each additional treatment phase would cost approximately $3,000,000. The amount of hydrogen

peroxide used in the second phase would have a direct impact on treatment costs. Although a 1 to 2 percent hydrogen peroxide solution is proposed, treatability studies may indicate that a stronger, or weaker, solution is required to chemically degrade waste pit contaminants.

**9.3.5.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 9-24.

### 9.3.6 Alternative WP-10: On-site Incineration

This subsection describes the on-site incineration alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the nine evaluation criteria.

**9.3.6.1 Description.** The on-site incineration alternative consists of: (1) constructing a diaphragm wall around each of the waste pits; (2) excavating waste pit soil to approximately 100 feet bgs; (3) incinerating the contaminated soil on site; and (4) backfilling the excavations with treated soil. Figure 9-20 shows a typical cross section of a waste pit after diaphragm wall construction and during waste pit soil excavation. Key components of the alternative are:

- mobilization and site preparation
- contaminated soil delineation (see Subsection 9.3.5.1)
- diaphragm wall construction
- excavation of contaminated soil
- incineration of contaminated soil (see Subsection 9.3.2.1)
- transportation of secondary waste streams for off-site treatment (see Subsection 9.3.2.1)
- backfill excavations

Contaminated soil delineation would be similar to that discussed in Subsection 9.3.5.1. Incineration of contaminated soil and transportation of secondary waste streams for off-site treatment would be similar to those discussed in Subsection 9.3.2.1. Other key components are discussed in the following paragraphs. The alternative design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

<u>Mobilization and Site Preparation</u>. A staging area for construction materials would be established west of the 1949 Pit. The proposed staging area is shown in

Figure 9-21. A portion of the staging area would be covered to protect diaphragm wall construction materials (e.g., bentonite and cement) from inclement weather. A parking area for a mobile laboratory, construction-support trailers, and heavy equipment would be located to the northwest of the 1949 Pit Area and would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot (see Figure 9-21).

The incinerator would be positioned on a level grade to the southwest of the 1949 Pit area (see Figure 9-21). The incineration facility would require approximately 3 acres for stockpiling of untreated and treated soils and 2 acres for the incinerator, auxiliary equipment, and operations trailers. The site for the incineration facility would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot. Because the excavated soil is potentially a RCRA hazardous waste (i.e., potentially failing the TCLP test for 24DNT), the untreated soil stockpile area would be designed and constructed to meet regulatory requirements for temporary storage of hazardous waste. These requirements would include lining and berming the stockpile area to contain runoff from stockpiled soil.

A concrete decontamination pad would be constructed in the parking area (see Figure 9-21). The pad would be used to decontaminate heavy equipment used during excavation. The pad would be designed to collect the decontamination water in a sump, and to pump or gravity-drain the water into a collection tank.

Equipment mobilized to the site would include the incinerator, diaphragm wall construction equipment, earth-moving equipment (i.e., cranes, backhoes, front-end loaders, and bulldozers), dumptrucks, and construction-support trailers.

<u>Diaphragm Wall Construction</u>. A circular diaphragm wall, consisting of structurally reinforced concrete or soil-concrete, would be constructed around each of the waste pits. The inside diameter of each ring would be approximately 110 feet and the wall panels would be placed to a depth of approximately 120 feet bgs. The wall would be constructed to tolerances that would minimize eccentricity and eliminate the need for internal bracing.

Specialized equipment is used to construct diaphragm walls. The method used by Nicholson Construction, of Bridgeville, PA, is explained here as an example of diaphragm wall construction (Pearlman, S.L., 1993).

Nicholson Construction uses HYDROMILL technology to excavate the trench, install a reinforcing cage, and concrete the trench, all under bentonite slurry to prevent collapse of the trench walls. The excavation and concreting process is conducted in stages as shown in Figure 9-22 and described below:

1. Pre-trench Excavation. A pretrench, 10 feet deep and the width of one primary panel, is excavated.

2. Primary Panel Excavation. The trench for the primary panel is excavated in three "bites"; two bites to the full depth followed by the wedge between.

3. Primary Panel Cage Installation. After the trench for the primary panel has been excavated, the reinforcing cage is installed.

4. Concreting the Primary Panel. Concrete is poured into the primary panel trench, displacing the bentonite slurry.

5. Construction of a Second Primary Panel. A second primary panel is constructed in line with the first panel but separated by a distance of slightly less than the width of the cutter drum assembly.

6. Secondary Panel Excavation. The trench for the secondary panel is excavated in a single bite, removing a small portion of the concrete on each adjacent primary panel.

7. Secondary Panel Cage Installation. After the trench for the secondary panel has been excavated, the reinforcing cage is installed.

8. Concreting the Secondary Panel. Concrete is poured into the secondary panel trench, displacing the bentonite slurry and creating a concrete-to-concrete construction joint with the primary panels.

Special features of the HYDROMILL equipment include two cutter drums equipped with tungsten carbide tipped teeth which rotate in opposite directions to excavate soil or rock, a dredge-type slurry pump situated above the cutter drums that pumps slurry with entrained cuttings to a desanding plant, and a verticality monitoring system which assists the operator in maintaining a vertical tolerance of 0.2 percent under normal conditions.

Excavation of Contaminated Soil. Contaminated soil would be excavated from the waste pits using cranes equipped with clamshells (see Figure 9-20). Dumptrucks equipped with liners would transport the soil to the stockpile area adjacent to the incinerator.

During excavation activities, an exclusion zone would be established that would encompass the site (see Figure 9-21). Excavation and handling equipment would operate within this zone and would not leave without first undergoing decontamination.

Backfill Excavations. Following removal of contaminated soil, stockpiled overburden, treated soil, and clean fill would be placed in the excavations, compacted to reduce settlement, and sloped to drain away from the excavation sites. The diaphragm walls would remain in place.

**9.3.6.2 Cost Estimate and Sensitivity Analysis.** For cost-estimating purposes, the following assumptions were made:

- 1-acre staging area
- 40-foot by 80-foot temporary shelter
- 0.5-acre parking area
- 0.25-acre untreated (hazardous) soil stockpile area
- 2.75-acre treated soil stockpile area
- one concrete decontamination pad
- 77 samples analyzed off site during contaminated soil delineation
- 24,400 cubic yards (36,600 tons) of contaminated soil per waste pit
- $3 million for incinerator mobilization/demobilization
- 109,800 tons of soil incinerated
- $200 per ton for incineration
- 7,320 cubic yards (10,980 tons) of fly ash for off-site disposal
- 108-mile one-way trip to off-site landfill (Menomonee Falls, WI)
- $4.75 per loaded mile
- $142.50 per ton for fly ash treatment (S/S) and disposal

The cost estimate for this alternative is shown in Table 9-25. Cost, material usage, and vendor information are provided in Appendices D.2, D.3, and D.4, respectively. Estimated remediation costs for this alternative are sensitive to a variation in the quantity of soil that must be excavated and incinerated. The distribution of waste pit soil samples collected during the RI was not sufficient to obtain an accurate

estimate of the lateral and vertical extent of contamination in waste pit soil (ABB-ES, 1993a). Consequently, the volume of contaminated soil could be significantly smaller, or larger, than that assumed (i.e., 24,400 cubic yards per pit) in the cost estimate for this alternative.

**9.3.6.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 9-26.

### 9.3.7 Alternative WP-11: In Situ Vacuum Extraction, Soil Washing, and Composting

This subsection describes the in situ vacuum extraction, soil washing and composting alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the nine evaluation criteria.

**9.3.7.1 Description.** The in situ vacuum extraction, soil washing and composting alternative consists of: (1) filling Waste Pit Nos. 2 and 3 with clay borrow; (2) installing and operating vacuum extraction wells in the filled waste pits to remediate VOCs (i.e., C6H6 and TRCLE) in the contaminated soil zone; (3) constructing a diaphragm wall around each of the waste pits; (4) excavating waste pit soil to approximately 100 feet bgs; (5) reducing the volume of contaminated soil by on-site soil washing; (6) on-site composting of the contaminated sludge from the soil washing process; and (7) backfilling the excavations with treated soil. Any excess material from the composting operation could be used for soil cover during remediation of PBG surface soil. Figure 9-23 is a flow diagram of the alternative, from filling Waste Pit Nos. 2 and 3 prior to in situ vacuum extraction through backfilling the excavations with treated soil. Key components of the alternative are:

- treatability testing
- contaminated soil delineation (see Subsection 9.3.5.1)
- in situ vacuum extraction system construction (see Subsection 9.3.4.1)
- in situ vacuum extraction system operation (see Subsection 9.3.4.1)
- site preparation and mobilization
- diaphragm wall construction (see Subsection 9.3.6.1)
- excavation of contaminated soil (see Subsection 9.3.6.1)
- soil washing contaminated soil
- composting contaminated sludge from soil washing
- backfill excavations

Contaminated soil delineation would be similar to that discussed in Subsection 9.3.5.1. In situ vacuum extraction system construction and operation would be similar to those discussed in Subsection 9.3.4.1. Diaphragm wall construction and excavation of contaminated soil would be similar to those discussed in Subsection 9.3.6.1. Other key components are discussed in the following paragraphs. The alternative design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

Treatability Testing. Pilot testing in the subsurface soils below the waste pits would be necessary in order to design an in situ vacuum extraction system. The pilot tests would determine: (1) the radius of influence of an extraction well relative to vacuums measured in the subsurface; (2) intrinsic permeability of the soil; (3) vacuum levels and flow rates that could potentially be achieved during full-scale operation; (4) soil vapor concentrations before, during, and after the pilot test; and (5) vapor concentrations in the extracted gases which would determine the most appropriate treatment approach for the blower effluent. The pilot test could include installation of one vacuum extraction well in the center of Waste Pit No.1 (currently filled) and three monitoring probe locations at discrete distances from the extraction well.

The extraction well would be screened from approximately 15 feet to 100 feet bgs. Inflatable packers could be used in the extraction well during the pilot test to isolate zones of contamination with different soil strata. The blower attached to the extraction well would be capable of extracting 100 scfm. Off-gases from the extraction well could be treated by passing them through activated carbon drums.

Each monitoring probe location could contain multiple probes positioned at different depths to determine the variation in air flow as a function of depth and differing soil strata. Probes located at different depths in the same well would be separated from each other by a bentonite or grout seal.

The pilot test would continue until at least one pore volume of vapor from the contaminated soil zone has been extracted, which is expected to take approximately 48 hours. Contaminant concentrations and/or vacuum would be measured at various locations in the monitoring, vapor extraction, and treatment systems during the test. Predictive models could be used to scale-up and design a full size system. The time required for treatability testing, including well construction, testing, and data interpretation, is estimated to be one month.

An independent investigation and assessment of international technologies applicable to hazardous waste sites in the United States revealed that soil washing has been used in the Netherlands and Germany for remediating sites impacted by a wide variety of contaminants (USEPA, 1988c). Soil washing has successfully treated soil contaminated with metals, solvents, PAHs, oil, PCBs, pesticides, and other chlorinated organics. A key similarity among all the soil washing units was that they operate on the principle that most of the contaminants are adsorbed to fine materials in the soil and segregation of "fines" from the other size fraction cleans the soil. Some of the units use very simple particle separation and wash water treatment technologies, while others employed more sophisticated extractants and cleaning agents. Although soil washing has apparently not been tested on explosives-contaminated soil, the principle of particle separation to clean the soil would still apply. As with other contaminated soil that has been successfully treated, the explosives are expected to be concentrated in the fines. In addition, explosives such as DNTs are moderately soluble in water and removal from coarse-grained material (i.e., sand), if required, would be enhanced by the use of surfactants.

Treatability testing for soil washing would be conducted in two phases (Mann, M.J., 1992). The first phase includes collection of a representative sample from the PBG waste pits and determination, through sieve analysis, the percentage finer curve and the contamination per fraction. Assuming results from the first phase indicate that soil washing is feasible, a second phase consisting of bench-scale testing would be conducted to aid in the selection of treatment units and to determine the surfactant, polymer, flow rate, and throughput requirements for a full-scale system. The time required for both phases of treatability testing is estimated to be four months.

The primary historical use for composting technology has been the treatment of municipal solid wastes, agricultural wastes, and wastewater treatment plant sludges. However, more recent interest has developed in its potential use for treatment of industrial wastes. The USAEC has conducted several pilot-scale composting studies to evaluate this technology for explosives-contaminated soils and sediments (Roy F. Weston, Inc., 1993b). Field demonstrations of composting explosives-contaminated (TNT, HMX, and RDX) and propellant-contaminated (NC) soils have been conducted at the Louisiana Army Ammunition Plant, BAAP, and the Umatilla Army Depot Activity (UMDA) and were successful in terms of reducing explosive concentrations through biotransformation. Initial TNT concentrations of as high as 17,872 mg/kg were reduced by greater than 99 percent (Roy F. Weston, Inc., 1988). Of the four explosives present in these experiments, TNT is the most rapidly transformed. Although composting of DNTs has not specifically been tested, data

from the AEC field demonstrations indicate that composting of DNT-contaminated soil should be successful. Literature on the subject of nitroaromatic degradation includes considerable information concerning degradation pathways and the relative biodegradability of TNT and DNT. In general, DNTs appear to degrade more quickly and completely than TNT. Degradative intermediates and their toxicities are known as well as the kinetics for various microorganisms (Suen, W.C. and J.C. Spain, 1993). While TNT biodegradation involves some potentially toxic and refractory intermediates, DNT biodegradation apparently proceeds to completion with little difficulty. Another product of the USAEC field demonstrations is a model that assists designers during bench-scale testing in the selection of composting parameters including amendments, soil-amendment ratios, and composting period (Brinton, W., 1994). Good correlation of the model results to the actual full-scale demonstration at UMDA were obtained.

Treatability testing for composting would be conducted immediately following completion of soil washing treatability testing. Contaminated sludge (i.e., soil fines) from soil washing would undergo bench-scale testing to identify the best combination and proportions of available soil amendments using an adiabatic composter to evaluate the temperature profile and respiration rates of each compost mixture. Availability of potential soil amendments (e.g., sawdust, alfalfa, chicken manure, cow manure, and potato waste) in the vicinity of BAAP would be determined prior to testing. Once a "compost recipe" is selected, further testing would be conducted to assess the effect of different soil loading rates on composting performance. Using the composting model from bench-scale testing, a full-scale process for composting waste pit soil could be designed. The time required for bench-scale testing is estimated to be two months.

Mobilization and Site Preparation. A staging area for construction materials would be established west of the 1949 Pit. The proposed staging area is shown in Figure 9-24. A portion of the staging area would be covered to protect diaphragm wall construction materials (e.g., bentonite and cement) from inclement weather. A parking area for a mobile laboratory, construction-support trailers, and heavy equipment would be located to the northwest of the 1949 Pit Area and would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot (see Figure 9-24).

The soil-wash treatment plant would be positioned on a level grade to the southwest of the 1949 Pit area (see Figure 9-24). The soil washing facility would require approximately 3 acres for stockpiling of untreated and treated soils and 1.5 acres for

the treatment plant, auxiliary equipment, and operations trailers. The site for the treatment plant would be prepared by grubbing, grading, placing an impermeable liner, and placing gravel to a minimum depth of 1 foot over the liner. Surface water run-on and run-off controls would be included. Because the excavated soil is potentially a RCRA hazardous waste (i.e., potentially failing the TCLP test for 24DNT), the untreated soil stockpile area would be designed and constructed to meet regulatory requirements for temporary storage of hazardous waste. Those requirements would include lining and berming the stockpile area to control surface water run-on and run-off.

The composting facility would be located west of the 1949 Pit area as shown in Figure 9-24. The contaminated sludge from soil washing would be stockpiled inside a temporary structure constructed on a bermed asphalt foundation pad. The stockpile structure would require approximately 0.5-acre, designed to stockpile about half of the total quantity of contaminated sludge at one time. Adjacent to the stockpile structure, an asphalted and bermed area would be prepared for the sludge-amendment mixing bins. North of the stockpile structure, four temporary structures for windrow composting would be constructed on a single asphalt foundation pad. Each structure would be 88 feet wide by 200 feet long. Structures by Sprung Structures, Inc., or equivalent, consisting of an external frame with plastic tensioned between the bars of the frame, would be suitable for this application. With allowances for room to maneuver the mechanical windrow turner between the structures and around the perimeter, the total area required for the windrow composting structures is approximately 3 acres.

Based on the above, the total combined area required for the soil washing and composting facilities (including stockpile/parking/staging areas) is approximately 10 acres.

Soil Washing Contaminated Soil. Although soil washing has a long history of successfully remediating contaminated soil in Europe, it has only recently gained acceptance in the United States. Consequently, few commercial-scale soil-wash treatment plants currently exist. A soil-wash plant operated by Alternative Remedial Technologies (ART), Inc. is used as an example for purposes of this evaluation. The "basic" ART treatment plant has a nominal throughput capacity of 25 tons per hour and has recently been used to treat soils and sludges contaminated with heavy metals at the King of Prussia Technical Corporation Superfund Site in Winslow, New Jersey (ART, Inc., 1993). The basic treatment plant has the flexibility to be modified to

treat soils contaminated with a wide range of contaminant species. A process flow schematic of the ART treatment plant is shown in Figure 9-25.

The first step in soil washing involves separating the soil fractions using various mechanical screening techniques and hydrocyclones. Based on the fact that there is a relationship between particle size and contaminant residence (contaminants generally are not bound to the oversize fraction), the gross oversize (>8 inches) and the oversize (>2 inches but <8 inches) materials would be mechanically screened out of the soil feed and returned to the excavations. A wet screen is used on material <2 inches where pea-sized gravel drops out and the rest of the material forms a slurry that is pumped to the next phase of separation (hydrocyclones). The coarse-grained sands (generally >40-60 microns but <2 inches) are centrifuged to the bottom, while the fine-grained materials (generally <40 to 60 microns) and the water separates to the top of the unit.

The coarse-grained materials would be treated in long, rectangular air flotation tanks that use mechanical aerators and diffused air. A selected surfactant (determined during the treatability test) would be used in these units to reduce the surface tension between the contaminant and the soil mass and separate the two fractions. The contaminant fraction forms a froth on the surface that is concentrated and usually directed to a sludge management belt filter press where it is dewatered into a 50-60 percent solids cake. The clean sand would then be dewatered and returned to the excavations. The water would be recycled back to the wet screening section.

The fine-grained materials and water from the hydrocyclones would be pumped to the sludge management subsystem. In the simplest case of treatment for fines, the slurry would be dosed with the polymer selected from the bench-scale tests and treated in a Lamella clarifier. The clarified solids would be thickened and then dewatered into a 50-60 percent solids cake using the sludge management belt filter press. The clarifier liquid would be recycled back into the system.

All equipment associated with the ART treatment plant is skid-mounted with quick disconnects and flexible connections as a basic design feature. The plant's primary utility requirements are water and electrical power. Water is completely recycled in the system; therefore no discharge is required, but make-up water at the rate of approximately 25 gpm is necessary. Depending upon the quality of the water recycled back into the treatment plant, wastewater treatment may be required to prevent recirculating contamination with the water. Wastewater treatment can be provided in a skid-mounted system. The same system could also be used to treat the

approximately 50,000 gallons of water remaining in the plant upon completion of soil treatment.

Composting Contaminated Sludge from Soil Washing. BAAP boring data indicates that the fines (i.e., passing the no. 200 sieve) content of the subsurface soil at the Propellant Burning Ground may range up to 5 percent by dry weight. Assuming the dry weight of the soil treated by soil washing is 90 percent of the total weight (i.e, 109,800 tons) and the sludge cake generated by the sludge management system is 50 percent solids, approximately 10,000 tons of sludge would require treatment in the composting facility. Consequently, a composting facility similar to the 6,000-ton facility described in Subsection 9.3.3.1 would be suitable for this alternative. Stockpile areas for contaminated sludge, amendment, and treated sludge would be increased proportionately to accommodate the increased volume of materials.

Because of the expected high concentrations of DNTs in the contaminated sludge the operation of the composting facility may differ from that in Subsection 9.3.3.1. The primary difference is anticipated to be the treatment period required to achieve RGs. While the composting period assumed for Alternative PBG-WP5 is 45 days, the composting period assumed for this alternative is 80 days.

Backfill Excavations. Following removal of contaminated soil, the excavations would be backfilled incrementally with stockpiled overburden and treated soil from the soil washing and composting facilities (see Figure 9-23). Gross oversize, oversize, and clean sand from the soil washing facility would be backfilled prior to backfilling treated soil from composting. Because excess compost would be available and it would be a rich organic mixture, it could be used for topsoil during construction of soil covers and/or RCRA caps at the PBG or other sites. Material placed in the excavations would be compacted to reduce settlement and sloped to drain away from the excavation sites. The diaphragm walls would remain in place.

**9.3.7.2 Cost Estimate and Sensitivity Analysis.** For cost-estimating purposes, the following assumptions were made:

- one vacuum extraction well per waste pit
- vacuum extraction and treatment systems are rented
- 4,000 lbs of activated carbon required to treat VOCs

- 1-acre staging area
- 40-foot by 80-foot temporary shelter
- 0.5-acre parking area
- 0.25-acre untreated (hazardous) soil stockpile area
- 2.75-acre treated soil stockpile area
- one concrete decontamination pad
- 77 samples analyzed off site during contaminated soil delineation
- soil washing treatability studies will cost $30,000
- composting treatability studies will cost $30,000
- three-phase power is not available
- 0.5-acre temporary structure, built on an asphalt pad, for contaminated sludge
- 24,400 cubic yards (36,600 tons) of contaminated soil per waste pit
- $100 per cubic yard for soil washing (includes mobilization and demobilization)
- 5 percent of the contaminated soil is fine-grained (by dry weight)
- 10,000 tons of contaminated sludge requires composting
- four purchased temporary structures, each 88 feet by 200 feet
- $50 per ton for amendment (cow manure, straw, alfalfa and vegetable wastes)
- soil would be 20 percent of total soil-amendment mixture

- composting period is 80 days

The cost estimate for this alternative is shown in Table 9-27. Cost, material usage, and vendor information are provided in Appendices D.2, D.3, and D.4, respectively. Estimated remediation costs for this alternative are sensitive to a variation in the quantity of soil that must be excavated and treated by soil washing and the quantity of contaminated sludge from soil washing that requires composting. The distribution of waste pit soil samples collected during the RI was not sufficient to obtain an accurate estimate of the lateral and vertical extent of contamination in waste pit soil (ABB-ES, 1993a). Consequently, the volume of contaminated soil could be significantly smaller, or larger, than that assumed (i.e., 24,400 cubic yards per pit) in the cost estimate for this alternative. Additionally, the assumed 5 percent fines content in waste pit soil was estimated using grain size distribution analyses performed on soils taken from a boring near the Settling Ponds. Although the subsurface soil types at the PBG and Settling Ponds are similar, there may be some variation in fines content.

**9.3.7.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 9-28.

### 9.3.8 Comparative Analysis of Alternatives

This subsection compares the relative advantages and disadvantages of the waste pit alternatives using the evaluation criteria. A comparative summary is provided in Table 9-29.

**9.3.8.1 Overall Protection of Human Health and the Environment.** Alternative PBG-WP1 would rely solely on institutional controls for protection of human health and does not eliminate or reduce the threat of groundwater contamination. Alternatives PBG-WP4 and PBG-WP5 would both use treatment, capping, and institutional controls to meet the remedial action objective for protection of human health. Although both Alternative PBG-WP4 and Alternative PBG-WP5 include caps designed to prevent infiltration of precipitation, a large quantity of contaminants (i.e., VOCs and DNTs) would remain close to the groundwater table and would continue to present a threat to groundwater quality. Alternative PBG-WP7 would also use treatment, capping, and institutional controls to meet remedial action objectives for protection of human health. However, Alternative PBG-WP7 provides a potentially higher degree of protection to groundwater than Alternatives PBG-WP4 and PBG-WP5 because VOCs, which are the more mobile soil contaminant, would

have been removed by in situ vacuum extraction. Alternatives PBG-WP8, PBG-10, and PBG-WP11 would all meet the remedial action objectives for protection of human health and groundwater by in situ treatment (i.e., PBG-WP8) or excavation and treatment (i.e., PBG-WP10 and PBG-WP11) of the entire volume of contaminated soil.

**9.3.8.2 Compliance with ARARs.** Alternative PBG-WP1 would not comply with pathway-specific numeric standards and could not achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of human health and groundwater. Although Alternatives PBG-WP4 and PBG-WP5 include excavation and treatment of severely contaminated soil, which would achieve pathway-specific numeric standards in the treated soil, unexcavated soil would not comply with pathway-specific numeric standards for protection of groundwater. It is possible that the RCRA caps used in Alternatives PBG-WP4 and PBG-WP5 could be designed to achieve a performance standard for protection of groundwater for unexcavated SVOC-contaminated soil, however, it is unlikely that the RCRA caps could achieve a performance standard for the more mobile VOCs remaining in the unexcavated soil. Alternative PBG-WP7 would also achieve pathway-specific numeric standards in soil that has been excavated and treated. In addition, in situ vacuum extraction used in Alternative PBG-WP7 could achieve pathway-specific standards for unexcavated VOC-contaminated soil and the caps could achieve a performance standard for protection of groundwater for unexcavated SVOC-contaminated soil. Consequently, Alternative PBG-WP7 could possibly meet either pathway-specific numeric standards or performance standards which would meet the intent of the proposed Chapter NR 720 clean-up standards. Alternatives PBG-WP8, PBG-WP10, and PBG-WP11 would all comply with pathway-specific numeric standards because the entire volume of contaminated soil would either be treated in situ (i.e., PBG-WP8) or excavated and treated (i.e., PBG-10 and PBG-WP11).

**9.3.8.3 Long-term Effectiveness and Permanence.** The long-term effectiveness and permanence of Alternative PBG-WP1 for protection of human health would be entirely dependent upon the implementation of plans to administer the waste pits. Failure to adequately administer the waste pits could result in significant exposure events such as construction-related invasive activities into contaminated soil. In addition, the long-term threat to groundwater quality would not be reduced. Because Alternatives PBG-WP4 and PBG-WP5 include excavation and treatment of severely contaminated soil, residual risk to human receptors would be negligible. However, the large quantity of unexcavated/untreated contaminants and the inherent mobility

of VOCs remaining in the unsaturated zone would pose a long-term threat to groundwater quality. Similar to Alternatives PBG-WP4 and PBG-WP5, Alternative PBG-WP7 would result in negligible residual risk to human receptors but the large quantity of unexcavated/untreated contaminants (i.e., SVOCs) remaining in the unsaturated zone would pose a long-term threat to groundwater quality. However, Alternative PBG-WP7 includes removal of the more mobile VOCs and could result in a reduced threat to groundwater quality, as compared to Alternatives PBG-WP4 and PBG-WP5. Alternatives PBG-WP8, PBG-WP10, and PBG-WP11 would be expected to treat the entire volume of contaminated soil either in situ (i.e., PBG-WP8) or after excavation (i.e., PBG-WP10 and PBG-WP11). Consequently, there would be no residual risk to human receptors or long-term threat to groundwater quality.

**9.3.8.4 Reduction in Toxicity, Mobility, and Volume through Treatment.** Destruction of waste pit contaminants is included in all the alternatives except PBG-WP1 (i.e., Minimal Action). Alternatives PBG-WP4 and PBG-WP5 would destroy an estimated 56,000 pounds of contaminants, by incineration and composting, respectively, but would leave the remainder untreated. Because Alternative PBG-WP7 includes in situ vacuum extraction of VOCs from the full depth of the contaminated soil zone, it would ultimately destroy a slightly greater quantity of contaminants than Alternatives PBG-WP4 and PBG-WP5. Alternative PBG-WP8 would destroy all waste pit contaminants either by off-site thermal reactivation of spent carbon (i.e., residuals from soil flushing) or by in situ chemical-biological degradation. Alternative PBG-WP10 would destroy all waste pit contaminants by incineration. Alternative PBG-WP11 would destroy all waste pit contaminants by off-site thermal reactivation of spent carbon (i.e., residuals from in situ vacuum extraction) and composting of contaminated soil washing sludge. Alternatives PBG-WP8, PBG-WP10, and PBG-WP11 would destroy an estimated 292,000 pounds of contaminants.

**9.3.8.5 Short-Term Effectiveness.** Of the waste pit alternatives evaluated, alternatives that include incineration (i.e., Alternatives PBG-WP4 and PBG-WP10) present the greatest risk to the community during implementation, but the risk is assumed to be within safe levels. For site workers, not only is there an ingestion/inhalation risk associated with excavating contaminated soil, but there is a reactive risk associated excavating and handling DNT-contaminated soil containing concentrations greater than 10 percent DNTs. Special precautions may be required during excavation and handling to prevent an explosive reaction. Alternatives that include in situ vacuum extraction (i.e., Alternatives PBG-WP7 and PBG-WP11) of

VOCs prior to excavation would reduce site worker inhalation risks associated with excavating VOC-contaminated soil.

**9.3.8.6 Implementability.** Waste pit alternatives that include incineration (i.e., Alternatives PBG-WP5 and PBG-WP10) have no associated technical implementability concerns. Minor implementability concerns are associated with Alternatives PBG-WP5 and PBG-WP11 because of the effects of site-specific (i.e., chemical and physical characteristics of site soil) and waste-specific (i.e., mix of waste pit contaminants) conditions on the composting and soil washing processes. Alternative PBG-WP8 potentially poses significant implementability concerns because in situ treatment using soil flushing or chemical-biological has never been applied to remediation of explosives-contaminated soil and never at this scale (i.e., contaminated soil volume that 110 feet in diameter and 100 feet deep). In addition, demonstrating that the barrier system provides complete containment of treatment chemicals and contaminants during in situ treatment may be difficult to demonstrate.

**9.3.8.7 Cost.** Alternative PBG-WP1 has the lowest capital cost (i.e., $10,000) compared to the other alternatives while Alternative PBG-WP11 has the highest capital cost (i.e., $35,006,000). Of the alternatives that include partial excavation and treatment (i.e., Alternatives PBG-WP4, PBG-WP5, and PBG-WP7), Alternative PBG-WP4 has a capital cost (i.e., $6,685,000) that is approximately 50 percent greater than that of Alternatives PBG-WP5 and PBG-WP7 (i.e., $4,219,000 and $4,444,000, respectively). However, Alternative PBG-WP4 has a significantly lower present worth operation and maintenance cost (i.e., $108,000) than that of Alternatives PBG-WP5 and PBG-WP7 (i.e., $1,141,000 each). Although soil flushing and chemical-biological in Alternative PBG-WP8 have similar capital costs (i.e., $12,691,000 and $11,987,000, respectively), the present worth operation and maintenance cost of soil flushing (i.e., $2,629,000) is less than a quarter that of chemical-biological (i.e., $12,287,000). Of the alternatives that include excavation and treatment of the entire volume of contaminated soil (i.e., Alternatives PBG-WP10 and PBG-WP11), Alternative PBG-WP11 has a capital cost (i.e., $35,006,000) that is more than 65 percent greater than that of Alternative PBG-WP10 (i.e., 20,941,000). However, Alternative PBG-WP11 has a present worth operation and maintenance cost (i.e., $3,303,000) that is almost 10 percent of the present worth operation and maintenance cost of Alternative PBG-WP10 (i.e., $28,641,000).

### 9.3.9 Selection of Preferred Alternative

Alternative PBG-WP11 (i.e., In Situ Vacuum Extraction, Soil Washing, and Composting) is the preferred alternative for waste pit remediation at the Propellant Burning Ground. The alternative would meet the remedial action objectives for protection of human health and groundwater by excavating and treating the entire volume of contaminated soil, and at a much lower cost than Alternative PBG-WP10 (i.e., On-Site Incineration). In conjunction with meeting remedial action objectives, the alternative would comply with pathway-specific numeric standards that were derived from the proposed Wisconsin Chapter NR 720. Alternative PBG-WP11 would ultimately destroy all waste pit contaminants using demonstrated processes that have a high probability of meeting remediation goals. A relatively short period of time (i.e., six months) is estimated for soil washing and composting treatability testing, during which in situ vacuum extraction could be implemented to remediate VOCs. In situ vacuum extraction would not only pretreat soil prior to soil washing and composting, it would also help protect site workers from VOCs that would otherwise volatilize into the atmosphere during excavation and soil washing.

## 9.4 GROUNDWATER ALTERNATIVES

**NOTE:** **Because regulatory approval of the preferred alternative as presented in the Draft Final FS has been obtained, design of the IRM modification has been completed, and bid documents have been prepared and were made available to prospective bidders on July 18, 1994 (see Section 1), this subsection was not revised subsequent to the Draft Final FS except to reflect use of WPALs rather WESs for remediation goals. Although costs for each remedial alternative would have increased to reflect new remediation goals and increased design (i.e., 3,000 gpm versus 2,000 gpm) flow rates from new extraction wells, the relative costs between alternatives are not expected to vary significantly from those presented in the Draft Final FS. In addition, the comparative analysis based on the other six evaluation criteria would not differ from that presented in the Draft Final FS.**

The following five groundwater remedial alternatives were retained for detailed analysis:

- Minimal Action (PBG-GW1)

- IRM and Carbon Adsorption (PBG-GW2)
- IRM and Air Stripping - Carbon Adsorption (PBG-GW4)
- IRM and Resin Adsorption (PBG-GW5)
- IRM and UV/Reduction - Carbon Adsorption (PBG-GW7)

Minimal Action was retained because it will serve as a baseline for the other groundwater alternatives. The other groundwater alternatives are designed to intercept, extract, and treat contaminated groundwater using the IRM facility and a new treatment facility (i.e., carbon adsorption, air stripping - carbon adsorption, resin adsorption, or UV/reduction - carbon adsorption). The new treatment facility would be constructed adjacent to the IRM facility. Effluent from the treatment facilities (i.e., IRM and new facility) would be discharged to the 10-inch diameter PVC pipeline that currently discharges effluent from the IRM facility to the Wisconsin River.

As discussed in Subsection 3.6.3, the new treatment facility would normally treat influent from the boundary control wells and the IRM facility would treat influent from the source control wells. Although influent from the boundary control wells is estimated to be 1,500 gpm, the new treatment facility would be designed for a maximum flow of 2,000 gpm. Designing the new facility for a maximum flow of 2,000 gpm would provide back-up capacity to the IRM facility in the event it fails or is shut down for maintenance and/or modification. The back-up capacity in the new facility would ensure uninterrupted pumping and treatment of groundwater from the source control wells, preventing recontamination of the aquifer downgradient of the Contaminated Waste Area. Additionally, a 2,000 gpm design flow could provide internal redundancy in the new treatment facility such that a portion of the treatment system could be removed from service for maintenance while the remainder of the system would have the capacity to continue treating average (i.e., 1,500 gpm) flows.

Alternatives PBG-GW2, PBG-GW4, PBG-GW5, and PBG-GW7 share the following components:

- site preparation and mobilization;
- extraction system construction;
- effluent pipe modification;
- IRM facility modification;
- IRM facility operation;
- treated groundwater discharge; and
- groundwater monitoring.

Because the above components are identical between the treatment alternatives, they will not be a factor in the comparative analysis of the treatment alternatives. However, they will be described and included in the detailed analysis.

Alternatives PBG-GW2, PBG-GW4, PBG-GW5, and PBG-GW7 differ in that they contain unique treatment technologies or treatment trains. Comparison will be largely based on the merits of their respective treatment technologies/trains. All the remedial alternatives are described and evaluated in detail in the following subsection.

### 9.4.1 Alternative PBG-GW1: Minimal Action

This subsection describes the minimal action alternative, provides a cost estimate, and evaluates the alternative using the nine criteria.

**9.4.1.1 Description.** The Minimal Action alternative serves as the baseline for groundwater remediation alternatives at the Propellant Burning Ground. The following components comprise this alternative:

Groundwater Monitoring. Continue the ongoing monitoring program defined in the October 30, 1992 "Modification of Conditional Plan Approval of In-field Conditions Report" (WDNR, 1992) attached as Appendix D.1. The purpose of this BAAP-wide sampling and analyses program is to monitor contamination migration and assess future environmental impacts. The monitoring locations, analytical parameters, and monitoring frequency pertinent to the Propellant Burning Ground are presented in Table 9-30. The locations for the Propellant Burning Ground monitoring wells identified in Table 9-30 are shown together with monitoring well locations for the BAAP-wide monitoring program in Figure 9-26.

Institutional Controls. Implement institutional controls in the form of deeds, zoning, or both if the site becomes inactive. The controls would restrict use of groundwater within and around the site. These controls would be drafted, implemented, and enforced in cooperation with state and local governments if the site became inactive.

Educational Programs. Conduct periodic public meetings and presentations to increase public awareness. This would help keep the public informed of the site status, including both its general condition and remaining contaminant levels. This could be accomplished by conducting annual presentations at public hearings

involving the appropriate regulatory agency. Findings from the monitoring program for the previous year could be presented and discussed at each hearing.

Five-Year Site Reviews. Under CERCLA 121c, any remedial action (or lack thereof) that results in contaminants remaining on site must be reviewed at least every five years. Data collected during the groundwater monitoring program would provide information for these reviews. The reviews would determine whether human health and the environment are protected. If appropriate, remedial actions may be initiated.

**9.4.1.2 Cost Estimate.** The present-worth cost of this alternative is estimated at \$7,435,000. This includes a capital cost of \$10,000, no indirect costs, and a total present-worth operating cost of \$7,425,000 (Table 9-31). Yearly costs for the ongoing groundwater monitoring program are from Olin Corporation (Olin, 1993). A 65-year monitoring program is used for costing purposes to be consistent with the estimated remediation time frame for those groundwater alternatives involving treatment.

Operating expenditures include installation costs for replacement of monitoring wells during years 16, 32, and 48 of the monitoring program. A failure rate of 2 percent of the wells being monitored is assumed.

**9.4.1.3 Alternative Evaluation.** The assessment of this alternative against the evaluation criteria is presented in Table 9-32.

### 9.4.2 Alternative PBG-GW2: IRM and Carbon Adsorption

This subsection describes the IRM and Carbon Adsorption alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the nine evaluation criteria.

**9.4.2.1 Description.** The IRM and Carbon Adsorption alternative consists of: (1) constructing the groundwater extraction system; (2) constructing a new carbon adsorption treatment facility adjacent to the existing IRM treatment facility; (3) modifying the existing 10-inch diameter effluent pipe; (4) modifying the existing IRM treatment facility; and (5) pumping and treating groundwater in the IRM facility and the new facility to remove groundwater contaminants (i.e., CCL4, 24DNT, 26DNT, CHCL3, TRCLE, 111TCE, NNDPA, BE, CD, CR, HG, PB, MN, and SO4). Figure 9-27 shows the proposed locations of the extraction system, IRM treatment facility, new treatment facility, and effluent pipe. The alternative would be designed

to meet the remedial action objectives for groundwater. Key components of the alternative are:

- site preparation and mobilization
- extraction system construction
- carbon adsorption treatment facility construction
- effluent pipe modification
- IRM facility modification
- carbon adsorption treatment facility operation
- IRM facility operation
- treated groundwater discharge
- groundwater monitoring (see Subsection 9.4.1.1)

Groundwater monitoring for this alternative would be similar to that discussed in Subsection 9.4.1.1. Other key components are discussed in the following paragraphs.

The entire facility (i.e., extraction, treatment, and discharge) design as described in the following paragraphs is preliminary and was developed for remedial alternative evaluation and cost-estimating purposes.

Site Preparation and Mobilization. A staging area for construction materials would be established near the existing IRM facility. A portion of the staging area would be covered to protect equipment from inclement weather. A parking area for heavy equipment and construction-support trailers would also be located adjacent to the IRM facility. The staging and parking areas would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot.

Equipment mobilized to the site would include earth-moving equipment (e.g., backhoes, front-end loaders, and bulldozers), drill rig(s), cranes, dump trucks, and construction-support trailers.

Extraction System Construction. A site-specific Propellant Burning Ground groundwater model was developed by ABB-ES to evaluate alternate groundwater extraction scenarios (ABB-ES, 1993a). The model extends from 1,500 feet north of the Propellant Burning Ground to 2,000 feet to the south of the southern BAAP boundary and approximately 1,500 feet east and west of the plume boundary. The total model area is approximately 10,125 feet long by 7,250 feet wide. A grid system consisting of 80 rows and 60 columns was superimposed on a map of the Propellant Burning Ground and vicinity to model the path of groundwater particles through the

site. The modeled thickness consists of five layers, representing three sand layers and two gravel layers of the overburden aquifer. A complete description of the model is provided in Appendix J of the Final RI Report (ABB-ES, 1993a).

After calibration and sensitivity analysis, the model was used to estimate extraction well placement, depth and length of screen within each well, and the pumping rates necessary to intercept the groundwater contaminant plume at the BAAP boundary and at a location downgradient of the contaminant source (i.e., Contaminated Waste Area).

The modeled pumping scheme simulates two extraction wells approximately 500 feet downgradient of the contaminant source and four extraction wells at the southern BAAP boundary (Figure 9-27).

The two source control extraction wells, identified as SCW-1 and SCW-2 in Figure 9-27, would be screened between approximately 95 and 170 feet bgs and would each have an estimated pumping rate of 250 gpm. SCW-1 and SCW-2 would capture contaminated groundwater as it flows from the source area and prevent it from migrating downgradient toward the BAAP boundary.

The four boundary control wells, identified as BCW-1, BCW-2, BCW-3, and BCW-4 in Figure 9-27, would be screened between approximately 115 to 185 feet bgs and would each have an estimated pumping rate of 375 gpm. The model results indicate the boundary control wells should be located approximately 1,350 feet, 1,925 feet, 2,450 feet and 2,900 feet east of the western BAAP boundary near the southern base boundary. Within the model, the wells were located immediately north of the southern perimeter road. The wells could be located up to 200 to 250 feet north of the southern perimeter road if a greater separation distance from existing or future monitoring wells located along the southern base boundary was needed. The boundary control wells would capture contaminated groundwater already present in the aquifer between the proposed locations of the source control wells and the BAAP boundary and prevent it from migrating downgradient toward the Wisconsin River.

Each extraction well would be 10 inches in diameter and constructed of stainless steel. Grain size of the sandpack material in the annular space around the screen would be compatible with the slot size of the screen. The remaining annular space would be backfilled and sealed with bentonite. Protective casings would be installed and cemented in place. Each boundary control well would contain a submersible pump or line-shaft turbine pump with sufficient pumping capacity to extract

groundwater at the rate specified for the well (i.e., estimated to be 375 gpm per well). Each source control well would contain a submersible or line-shaft turbine pump with sufficient pumping capacity to extract groundwater at the rate specified for the well (i.e., estimated to be 250 gpm per well) plus additional pumping capacity that could be utilized in the event the neighboring well or well pump was to fail. Providing back-up capacity in the source control well pumps would reduce the possibility of recontamination of the aquifer downgradient of the Contaminated Waste Area in the event one of the source control wells failed. For purposes of the FS, the pumps are stainless steel submersible pumps. Each boundary control well would be rated for 375 gpm at a TDH of 230 feet (30 horsepower [hp]) and each source control well would be rated for 500 gpm at a TDH of 200 feet (35 hp) (Appendix D.6).

The groundwater extracted from each source control well would be pumped to a buried 6-inch diameter influent pipe constructed for transport of groundwater to the treatment facilities (see Figure 9-27). The existing influent pipe from the IRM facility source control well could be used in conjunction with or as back-up to the new influent pipe.

The groundwater extracted from each boundary control well would be pumped to a buried 10-inch diameter influent pipe constructed for transport of groundwater to the treatment facilities (see Figure 9-27). The influent pipe would be routed through the Final Creek culvert under the railroad tracks (see Figure 9-27).

The process of collecting groundwater via extraction wells would effectively dilute the concentrations of contaminants as detected in monitoring wells at the Propellant Burning Ground. For purposes of the FS, contaminant concentrations in groundwater pumped from the new boundary control wells is assumed to be equivalent to the average concentration currently detected in the IRM facility influent (Olin, 1992). Contaminant concentrations in groundwater pumped from the new source control wells is assumed to be equivalent to concentrations currently detected in groundwater pumped from the existing IRM facility source control well (Olin, 1992). The groundwater contaminants originally identified in Table 3-8 were tabulated along with maximum contaminant concentrations detected in monitoring wells at the Propellant Burning Ground, contaminant concentrations assumed for the influent from the boundary control wells, and contaminant concentrations assumed for the influent from the source control wells (Table 9-33).

Using current IRM facility influent concentrations to be representative of groundwater pumped from the new boundary control wells is considered a conservative assumption. The IRM facility currently treats groundwater from one source control well located on the south side of the Contaminated Waste Area and three boundary control wells located east-southeast of the IRM facility (see Figure 9-27). Generally speaking, the existing source control well extracts groundwater contaminated with relatively high levels of DNTs while the existing boundary control wells extract groundwater contaminated with relatively high levels of VOCs. Consequently, representative levels of DNTs and VOCs are included in the assumed influent concentrations from the new boundary control wells. Additionally, dilution is expected to occur when pumping rates at the new boundary control wells are increased to 1,500 gpm, resulting in increased advection and hydrodynamic dispersion. The net result is likely to be lower actual influent concentrations than the influent concentrations from boundary control wells shown in Table 9-33.

Using contaminant concentrations in groundwater pumped from the existing IRM facility source control well to be representative of groundwater pumped from the new source control wells is also considered a conservative assumption. Although the new source control wells would be located in approximately the same location as the existing source control well, increasing the combined pumping rate to 500 gpm would result in increased advection and hydrodynamic dispersion and dilution of influent concentrations.

Estimated surface water discharge limits are presented beside the assumed influent concentrations in Table 9-33 to show the magnitude of treatment potentially required for groundwater contaminants. The estimated surface water discharge limits assume that treatment can attain greater than 99 percent removal of groundwater contaminants (WDNR, 1990b).

The USEPA batch flushing model was used to estimate cleanup times for the Propellant Burning Ground aquifer. The model assumes there are no continuing sources of contamination, as would be effectively achieved by the new source control wells. The model results depend on soil bulk density, organic carbon partition coefficient of the contaminant, organic carbon fraction in the aquifer, and aquifer porosity. Table 9-34 presents a summary of the calculated estimates of cleanup times for the major organic contaminants in the Propellant Burning Ground aquifer. Calculations are contained in Appendix D.6.

As shown in Table 9-34, the organic carbon fraction in the aquifer has a significant effect on the model results. The estimated value for organic carbon fraction, as reported in the RI report, is less than 0.003 (ABB-ES, 1993a). A range of 0.0001 to 0.001 was used in the calculations to illustrate the effects of the parameter. Assuming the more conservative value of 0.001, the number of pore volumes (i.e., flushes) required to attain WESs for the contaminants ranged from 2.3 (for CHCL3) to 4.8 (for 26DNT). Using the Propellant Burning Ground groundwater flow model, the estimated groundwater travel time from the Racetrack Area to the southern BAAP boundary is approximately 18 years. Multiplying the number of pore volumes required for aquifer remediation by the travel time yields an estimated cleanup time of 41 (for CHCL3) to 86 (for 24DNT) years. For purposes of the FS, the approximate median cleanup time of 65 years is used to estimate treatment facility operation and maintenance costs.

<u>Carbon Adsorption Treatment Facility Construction</u>. A permanent groundwater treatment facility would be constructed adjacent to the IRM facility (see Figure 9-27). The building would be a pre-engineered structure installed on a reinforced concrete pad. A sump would be built into the pad to collect spilled liquids and recirculate them back into the treatment system. Electrical service would be supplied to the treatment facility for lights, heating/ventilation/air conditioning (HVAC), and operation of the treatment systems. The maximum electrical load in the new facility is expected to be approximately 325 kilowatts (KW). Because the electrical service to the IRM facility is currently 192 kilovolt amp (KVA) (i.e., 400A/480V/3-phase), additional service would have to be brought to the site. The nearest source that is capable of providing sufficient electricity to the treatment facility is a 12,470V three-phase power transmission line that passes approximately 200 feet from the IRM facility (Thurow, 1993). An electrical substation incorporating a 0.5 megavolt amp (MVA) transformer and associated switchgear would be constructed near the treatment facilities to step down the voltage for treatment system use.

Water would be supplied to the new facility for maintenance and cleaning activities. A branch line off the existing water line to the IRM facility would be constructed to the new facility for that purpose.

A 6-inch diameter branch line off the IRM influent (i.e., influent from the source control wells) line would be constructed to the new facility. The branch line would allow treatment plant operators to divert flow from the source control wells to the new facility in the event the IRM treatment system fails or is shut down for maintenance and/or modification. A 10-inch diameter pipe would be constructed

from the new facility to the IRM facility for transport of effluent to the existing effluent pipe.

Equipment installed in the new treatment facility would include a filter assembly, an influent equalization tank, one average-flow (i.e., 1,500 gpm) influent transfer pump, one maximum-flow (i.e., 2,000 gpm) influent transfer pump, the carbon adsorption system, an effluent tank, one average-flow effluent transfer pump, and one maximum-flow effluent transfer pump (Figure 9-19). The filter assembly would consist of two parallel filters, each filter containing 12 filter bags and rated for 2,000 gpm maximum flow. The influent equalization tank would have a 5,000-gallon capacity (additional capacity would not be necessary because the pumping and treatment flows would typically be constant). The average-flow influent transfer pump would be rated for 1,500 gpm at a TDH of 55 feet (30 hp). The maximum-flow influent transfer pump would be rated for 2,000 gpm at a TDH of 95 feet (65 hp). The carbon adsorption system would consist of two parallel trains of 2x20,000 lb. skid-mounted carbon vessels (see Figure 9-28). Each carbon vessel would have a diameter of 12 feet. The effluent tank would have a 5,000 gallon-capacity. The average-flow effluent transfer pump would be rated for 1,500 gpm at a TDH of 325 feet (165 hp). The maximum-flow effluent transfer pump would be rated for 2,000 gpm at a TDH of 325 feet (220 hp). The flow (i.e., 2,000 gpm) and the TDH (i.e., 325 feet) in the effluent pipe would be constant regardless of whether it is combined flow from the IRM and the new facility or it is flow from the new facility alone.

Floor space required for the new treatment facility building was estimated using the following dimensions for treatment system equipment:

- Filter Assembly. Floor space required for the filter assembly is estimated to be 8 by 12 feet.
- Tanks. Tank diameter is assumed to be 12 feet for the influent equalization and effluent tanks.
- Influent Transfer Pumps. Floor space required for the influent transfer pumps is estimated to be 6 by 8 feet.
- Carbon Adsorption System. Skid dimensions are approximately 10 by 30 feet for each 2x20,000 lb. carbon vessel skid.

- Effluent Transfer Pumps. Floor space required for the effluent transfer pumps is estimated to be 8 by 10 feet.

Allowing for approximately 500 square feet for a office/control center and storage space, the floor space required for the building is estimated to be 3,200 square feet. For preliminary design and cost-estimating purposes, the building would occupy a foot print of 40 by 80 feet.

Effluent Pipe Modification. The length (i.e., from the IRM facility to the Wisconsin River) of the existing 10-inch diameter effluent pipe is approximately 14,000 feet. The first 3,500 feet (i.e., from the IRM facility to its maximum elevation east-southeast of the IRM facility) of the effluent pipe is force main. The remaining 10,500 feet (i.e., from its maximum elevation to the Wisconsin River) is gravity main. Three manholes are located along its length. One manhole is located at the pipe's maximum elevation (see Figure 9-27) and two manholes are located near the Wisconsin River. The effluent pipe currently transports a maximum flow of 400 gpm.

Modifications will be necessary when flows increase to 2,000 gpm. A flow of 2,000 gpm would generate a TDH of approximately 325 feet. The drop in elevation from the pipe's maximum elevation to the Wisconsin River is not sufficient to maintain gravity flow. Consequently, one of two options would be implemented: (1) convert all of the existing effluent pipe to force main; or (2) construct a second gravity main from the pipe's maximum elevation to the Wisconsin River to supplement the existing gravity main. A cost comparison between the two options was conducted. Construction (i.e., constructing a second gravity main) and pumping costs (i.e., 65-year project life) were considered for the cost comparison. Present worth for the two options was similar (i.e., $1.2 million). Calculations for the cost comparison are provided in Appendix D.6.

For purposes of the FS, the selected option is conversion of the existing effluent pipe to force main. Implementation would be more rapid and fewer environmental impacts would result. However, this option requires closer examination because operating pressures may exceed the design pressure (150 psi) of the existing pipe and there would be limitations on the pipe receiving flow from other BAAP discharges.

At a minimum, modifications to the existing effluent pipe would include splicing in sections of 10-inch diameter pipe at the manholes and installing air/vacuum relief valves at high points in the pipe.

<u>IRM Facility Modification</u>. The existing IRM facility would continue to operate during construction of the new extraction system and treatment facility. The IRM facility would be modified to treat increased groundwater flows after the new extraction system and treatment facility are on line.

The existing IRM treatment system was designed to treat an average flow of 250 gpm and a maximum flow of 400 gpm. Figure 9-28 includes a flow diagram of the treatment system and shows the major components of the system. The two carbon vessels are used for primary treatment of groundwater and the air stripper is used to polish the effluent prior to discharge to Lake Wisconsin.

After the new treatment facility is on line and treating groundwater from the new extraction system, modification of the IRM facility would be required to increase its capacity to treat all of the flow (i.e., 500 gpm) from the source control wells. As determined and described in Subsection 3.6.3, the IRM facility would be dedicated to treatment of groundwater pumped from the source control wells.

At a minimum, the influent transfer pump and the effluent transfer pump would be replaced with higher capacity pumps. Other modifications that could occur would be: (1) replacement of the bag filters with a higher flow capacity duplex filter system that could be operated at full flow (i.e., 500 gpm) during maintenance and/or replacement of one of the filters; and (2) replacement of the air stripper blower with a higher capacity blower if the same air-to-water ratio (i.e., 150:1) as is currently used is maintained. A modification that is unrelated to increased flows but could result in improved IRM treatment system operation is installation of a bypass line that routes effluent from the carbon adsorption system around the air stripper to the air stripper sump. The bypass line could be used when there is a low probability for residual contaminants in the carbon adsorption system effluent (i.e., after replacement of spent carbon). At such times, the air stripper blower could be shut off and the effluent routed directly to the air stripper sump. The net result would be lower operating costs and reduced scaling from calcium carbonate precipitation as is currently experienced during air stripper operation.

For the purposes of the FS, it assumed that the only modification to the IRM treatment system is replacement of the influent and effluent transfer pumps. The influent transfer pump would be replaced with a pump rated for 500 gpm at a TDH of 150 feet (25 hp). The effluent transfer pump would be replaced with a pump rated for 500 gpm at a TDH of 325 feet (55 hp).

Carbon Adsorption Treatment Facility Operation. New treatment facility operation would be dedicated to treatment of influent from the boundary control wells. The assumed contaminant concentrations in the influent from the boundary control wells and the estimated surface water discharge limits are presented in Table 9-33.

Operation of the new treatment facility would consist of pumping (with the extraction well pumps) contaminated groundwater through the filter assembly and into the influent equalization tank. The influent transfer pumps would pump water from the equalization tank through the carbon adsorption system to the effluent tank. The effluent transfer pump would pump water from the effluent tank through the effluent pipe to the Wisconsin River (see Figure 9-28).

Routine operation and maintenance practices would include replacement of spent carbon in the lead carbon vessels upon CHCL3 breakthrough (i.e., detectable concentrations of CHCL3 in the lead vessel effluent). During carbon replacement in the lead vessels, all treatment system flow would be diverted to the polishing vessels so there is no interruption in treatment system operation. After carbon replacement in the lead vessels, the flow path through the carbon vessels would be switched by following a prescribed valve sequence so that the polishing vessel becomes the lead vessel and the lead vessel becomes the polishing vessel in the series configuration.

Using the assumed influent contaminant concentrations presented in Table 9-33 for input parameters, modeling of the rate of carbon saturation at 1,500 gpm indicates that CHCL3 breakthrough in each lead vessel would occur approximately every 60 days of new treatment system operation (Rogers, 1993a). Consequently, approximately 12 rebeds would be required per year (i.e., six rebeds per lead vessel per year multiplied by two vessels) . The modeled rate of carbon saturation assumes the use of virgin carbon for rebed material. Virgin carbon has a higher capacity for adsorbed contaminants than reactivated carbon.

Filter elements would be replaced when there is excessive pressure drop across the filters. During element replacement, treatment system flow would be diverted to the parallel filter in the filter assembly so that there is no interruption in treatment system operation.

For purposes of the FS, bi-weekly sampling and analysis would be required to monitor performance of the treatment system. One sample would be collected from each of the following three locations: (1) from the treatment system influent;

(2) from an intermediate point between the carbon vessels; and (3) from the treatment system effluent. Each sample would be analyzed for groundwater contaminants as specified in Table 9-35. Table 9-35 also presents USEPA analytical methods for the contaminants.

IRM Facility Operation. IRM treatment facility operation would be dedicated to continuous treatment of influent from the source control wells. The assumed contaminant concentrations in the influent from the source control wells and the estimated surface water discharge limits are presented in Table 9-33.

Operation of the IRM treatment facility would consist of pumping (with the extraction well pumps) contaminated groundwater through the filter assembly and into the influent equalization tank. The influent transfer pump would pump water from the equalization tank through the carbon adsorption system and the air stripper to the air stripper sump (see Figure 9-28). The effluent transfer pump would pump water from the sump to the effluent pipe and the Wisconsin River.

Operating practices would include replacement of spent carbon in the lead carbon vessel upon CHCL3 breakthrough (i.e., detectable concentrations of CHCL3 in the lead vessel effluent). During carbon replacement in the lead vessel, all treatment system flow would be diverted to the polishing vessel so there is no interruption in treatment system operation. After carbon replacement in the lead vessel, the flow path through the carbon vessels would be switched by following a prescribed valve sequence so that the polishing vessel becomes the lead vessel and the lead vessel becomes the polishing vessel in the series configuration.

Using the assumed influent contaminant concentrations presented in Table 9-33 for input parameters, modeling of the rate of carbon saturation at 500 gpm indicates that CHCL3 breakthrough would occur approximately every 60 days of the IRM treatment system operation (Rogers, 1993a). Consequently, approximately six rebeds would be required per year. The modeled rate of carbon saturation assumes the use of virgin carbon for rebed material. Virgin carbon has a higher capacity for adsorbed contaminants than reactivated carbon.

Filter elements would be replaced when there is excessive pressure drop across the filters. If possible, treatment system flow would be diverted to the parallel filter in the filter assembly so that there is no interruption in treatment system operation.

For purposes of the FS, bi-weekly sampling and analysis would be required to monitor performance of the treatment system. One sample would be collected from each of the following four locations: (1) from the treatment system influent; (2) from a location between the carbon vessels; (3) from a location between the carbon adsorption system and the air stripper; and (4) from the treatment system effluent. Each sample would be analyzed for groundwater contaminants as specified in Table 9-35. Table 9-35 also presents USEPA analytical methods for the contaminants.

Treated Groundwater Discharge. The effluent from the new treatment facility and the IRM treatment facility would be discharged to the modified 10-inch diameter effluent pipe.

For purposes of the FS, it is assumed that the Wisconsin Pollutant Discharge Elimination System (WPDES) permit issued for the combined treatment system effluent would require weekly sampling from a sampling point located along the pipeline. The sample would be analyzed for Propellant Burning Ground groundwater contaminants. USEPA analytical methods for the contaminants are presented in Table 9-35.

**9.4.2.2 Cost Estimate and Sensitivity Analysis**. For cost-estimating purposes, the following assumptions were made:

- IRM treatment facility would treat an average 500 gpm,
- carbon adsorption treatment facility rated for 2,000 gpm, but would treat an average 1,500 gpm
- six carbon vessel rebeds per year in IRM facility ($15,500 per rebed)
- 12 carbon vessel rebeds per year in carbon adsorption treatment facility ($15,500 per rebed)
- spent carbon transported off site for thermal reactivation

The cost estimate for this alternative is shown in Table 9-36. Cost, material usage, and vendor information are provided in Appendices D.5, D.6, and D.7, respectively. Estimated remediation costs for this alternative are sensitive to a variation in the cost for carbon replacement in the IRM facility and new facility. Off-site transport and

thermal reactivation of spent carbon is heavily regulated and changes in regulations over the life (i.e., 65 years) of the project could result in significant increases in operating costs for this alternative.

**9.4.2.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 9-37.

### 9.4.3 Alternative PBG-GW4: IRM and Air Stripping - Carbon Adsorption

This subsection describes the IRM and Air Stripping - Carbon Adsorption alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the nine evaluation criteria.

**9.4.3.1 Description.** The IRM and Air Stripping - Carbon Adsorption alternative consists of: (1) constructing the groundwater extraction system; (2) constructing a new air stripping - carbon adsorption treatment facility adjacent to the existing IRM treatment facility; (3) modifying the existing 10-inch diameter effluent pipe; (4) modifying the existing IRM treatment facility; (5) pumping and treating groundwater in the IRM facility and the new facility to remove groundwater contaminants (i.e., CCL4, 24DNT, 26DNT, CHCL3, TRCLE, 111TCE, NNDPA, BE, CD, CR, HG, PB, MN, and SO4); and (6) discharging the treated groundwater to Lake Wisconsin through the modified 10-inch diameter effluent pipe. Figure 9-27 shows the proposed locations of the extraction system, IRM treatment facility, new treatment facility, and effluent pipe. The alternative would be designed to meet the remedial action objectives for groundwater. The key components of the alternative are:

- site preparation and mobilization (see Subsection 9.4.2.1)
- extraction system construction (see Subsection 9.4.2.1)
- air stripping - carbon adsorption treatment facility construction
- effluent pipe modification (see Subsection 9.4.2.1)
- IRM facility modification (see Subsection 9.4.2.1)
- air stripping - carbon adsorption treatment facility operation
- IRM facility operation (see Subsection 9.4.2.1)
- treated groundwater discharge (see Subsection 9.4.2.1)
- groundwater monitoring (see Subsection 9.4.1.1)

Site preparation and mobilization, extraction system construction, effluent pipe modification, IRM facility modification, IRM facility operation, and treated

groundwater discharge for this alternative would be similar to those discussed in Subsection 9.4.2.1. Groundwater monitoring for this alternative would be similar to that discussed in Subsection 9.4.1.1. The other key components are discussed in the following paragraphs.

The entire facility (i.e., extraction, treatment, and discharge) design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

<u>Air Stripping - Carbon Adsorption Treatment Facility Construction</u>. A permanent groundwater treatment facility would be constructed adjacent to the IRM facility (see Figure 9-27). The building would be a pre-engineered structure installed on a reinforced concrete pad. A sump would be built into the pad to collect spilled liquids and recirculate them back into the treatment system. Electrical service would be supplied to the treatment facility for lights, HVAC, and operation of the treatment systems. The maximum electrical load in the new facility is expected to be approximately 450 KW. Because the electrical service to the IRM facility is currently 192 KVA (i.e., 400A/480V/3-phase), additional service would have to be brought to the site. The nearest source that is capable of providing sufficient electricity to the treatment facility is a 12,470V three-phase power transmission line that passes approximately 200 feet from the IRM facility (Thurow, 1993). An electrical substation incorporating a 0.5 MVA transformer and associated switchgear would be constructed near the treatment facilities to step down the voltage for treatment system use.

Water would be supplied to the new facility for maintenance and cleaning activities. A branch line off the existing water line to the IRM facility would be constructed to the new facility for that purpose.

A 6-inch diameter branch line off the IRM influent (i.e., influent from the source control wells) line would be constructed to the new facility. The branch line would allow treatment plant operators to divert flow from the source control wells to the new facility in the event the IRM treatment system fails or is shut down for maintenance. A 10-inch diameter pipe would be constructed from the new facility to the IRM facility for transport of effluent to the existing effluent pipe.

Equipment installed in the new treatment facility would include a filter assembly, an influent equalization tank, one average-flow (i.e., 1,500 gpm) influent transfer pump, one maximum-flow (i.e., 2,000 gpm) influent transfer pump, the air stripper system,

an air stripper sump, one average-flow air stripper sump pump, one maximum-flow air stripper sump pump, the carbon adsorption system, an effluent tank, one average-flow effluent transfer pump, and one maximum-flow effluent transfer pump (Figure 9-29). The filter assembly would consist of two parallel filters, each filter containing 12 filter bags and rated for 2,000 gpm maximum flow. The influent equalization tank would have a 5,000-gallon capacity (additional capacity would not be necessary because the pumping and treating flows would typically be constant). The average-flow influent transfer pump would be rated for 1,500 gpm at a TDH of 60 feet (30 hp). The maximum-flow influent transfer pump would be rated for 2,000 gpm at a TDH of 70 feet (50 hp). The air stripper system would consist of three 6-foot diameter air strippers. Each air stripper would be equipped with a 25 KW heater and two vapor-phase carbon adsorption canisters for off-gas treatment. Calculations of the mass of groundwater contaminant emissions from air strippers treating 1,500 gpm at the influent concentrations listed in Table 9-33 indicate that the mass of CCL4 emitted from the air strippers would exceed the mass allowed per Wisconsin Hazardous Air Pollutants Emissions Standards (Chapter NR 445) (i.e., 126 lbs/year versus 25 lbs/year, respectively). The vapor-phase carbon adsorption canisters on each of the air strippers would eliminate CCL4 emissions into the atmosphere. The average-flow air stripper sump pump would be rated for 1,500 gpm at a TDH of 55 feet (30 hp). The maximum-flow air stripper sump pump would be rated for 2,000 gpm at a TDH of 95 feet (65 hp). The carbon adsorption system would consist of two parallel trains of 2x20,000 lb. skid-mounted carbon vessels (see Figure 9-29). Each carbon vessel would have a diameter of 12 feet. The effluent tank would have a 5,000-gallon capacity. The average-flow effluent transfer pump would be rated for 1,500 gpm at a TDH of 325 feet (165 hp). The maximum-flow effluent transfer pump would be rated for 2,000 gpm at a TDH of 325 feet (220 hp). The flow (i.e., 2,000 gpm) and the TDH (i.e., 325 feet) in the effluent pipe would be constant regardless of whether it is combined flow from the IRM and the new facility or is flow from the new facility alone.

Floor space required for the new treatment facility building was estimated using the following dimensions for treatment system equipment:

- Filter Assembly. The foot print of the filter assembly is estimated to be 8 by 12 feet.

- Tanks. Tank diameter is assumed to be 12 feet for the influent equalization, air stripper sump, and effluent tanks.

- Influent Transfer Pumps and Blowers. The foot print of the skid that supports the influent transfer pumps and air stripper blowers is estimated to be 8 by 8 feet.

- Air Strippers. The foot print of each air stripper is estimated to be 8 by 8 feet.

- Air Stripper Sump Pumps. The foot print of the air stripper sump pumps is estimated to be 6 by 8 feet.

- Carbon Adsorption System. Skid dimensions are 10 by 30 feet for each of the 2x20,000 lb. carbon vessel skids.

- Effluent Transfer Pumps. The foot print of the effluent transfer pumps is estimated to be 8 by 10 feet.

Allowing for approximately 500 square feet for a office/control center and storage space, the floor space required for the building is estimated to be 5,000 square feet. For preliminary design and cost-estimating purposes, the building would occupy a foot print of 50 by 100 feet.

Air Stripping - Carbon Adsorption Treatment Facility Operation. New treatment facility operation would be dedicated to continuous treatment of influent from the boundary control wells. The assumed contaminant concentrations in the influent from the boundary control wells and the estimated surface water discharge limits are presented in Table 9-33.

Operation of the new treatment facility would consist of pumping (with the extraction well pumps) contaminated groundwater through the filter assembly and into the influent equalization tank. The influent transfer pump would pump water from the equalization tank to the air strippers that discharge into the air stripper sump. Air emissions from the air strippers would pass through the vapor-phase carbon units prior to discharge into the atmosphere. The air stripper sump pump would pump water from the air stripper sump through the carbon adsorption system to the effluent tank. The effluent transfer pump would pump water from the effluent tank through the effluent pipe to the Wisconsin River. To provide maximum efficiency during average-flow operation, the 1,500 gpm pumps would be used during routine treatment plant operation. To provide maximum efficiency during maximum-flow

operation, the 2,000 gpm pumps would be used when flow from the source control wells is diverted to the new facility (i.e., during IRM facility shut down).

Removal of C6H6, 111TCE, CCL4, CHCL3, 12DCLE, and TRLCE would primarily occur in the air strippers. Routine operation and maintenance practices would include replacement of vapor-phase carbon canisters upon CHCL3 breakthrough (i.e., detectable concentrations of CHCL3 in canister effluent). To prevent interruption of treatment system operation during carbon canister replacement, influent groundwater could be diverted around the air stripper(s) and be discharged directly to the air stripper sump.

Using the assumed influent contaminant concentrations presented in Table 9-33 for input parameters and assuming 12,000 lb carbon canisters are used for vapor-phase treatment, modeling of the rate of vapor-phase carbon saturation indicates that CHCL3 breakthrough would occur approximately every six years of new treatment system operation (Rogers, 1993a). Consequently, approximately three carbon canisters would be replaced every six years (i.e., one carbon canister per air stripper every six years multiplied by three air strippers). The modeled rate of carbon saturation assumes the use of virgin carbon for rebed material. Virgin carbon has a higher capacity for adsorbed contaminants than reactivated carbon.

Polishing of C6H6, 111TCE, CCL4, CHCL3, 12DCLE, and TRCLE and removal of 24DNT, 26DNT, and NNDPA would occur in the aqueous-phase carbon adsorption system. Routine operation and maintenance practices would include replacement of spent carbon in the lead carbon vessels upon breakthrough (i.e., detectable concentrations of a contaminant in the lead vessel effluent). During carbon replacement in the lead vessels, all treatment system flow would be diverted to the polishing vessel so that there is no interruption in treatment system operation. After carbon replacement in the lead vessel, the flow path through the carbon vessels would be switched by following a prescribed valve sequence so that the polishing vessel becomes the lead vessel and the lead vessel becomes the polishing vessel in the series configuration.

Modeling of the rate of aqueous-phase carbon saturation at 1,500 gpm indicates that breakthrough in each lead vessel would occur approximately every eight months of new treatment system operation (Rogers, 1993a). Consequently, approximately three rebeds would be required every year (i.e., 1.5 rebeds per lead vessel per year multiplied by two lead vessels). The modeled rate of aqueous-phase carbon

saturation assumes the use of virgin carbon for rebed material. Virgin carbon has a higher capacity for adsorbed contaminants than reactivated carbon.

Filter elements would be replaced when there is excessive pressure drop across the filters. During element replacement, treatment system flow would be diverted to the parallel filter in each filter assembly so there is no interruption in treatment system operation.

Incrustation in the form of calcium carbonate precipitation and scaling is occurring in the existing IRM treatment system downstream of the air stripper (Fordham, 1992). Scaling has been so severe that it has been necessary to shut down the system to remove scale from the effluent transfer pump and process flow instrumentation. To prevent a similar occurrence from happening in the new treatment facility, it may be necessary to feed an acidic solution into the process stream upstream of the air strippers. This would reduce pH and may prevent oversaturation of calcium carbonate in the water. Testing of the effectiveness of pH adjustment for reducing calcium carbonate precipitation would be conducted in the IRM facility prior to Air Stripping - Carbon Adsorption facility construction.

For purposes of the FS, bi-weekly sampling and analysis would be required to monitor performance of the treatment system. One sample would be collected from each of the following four locations: (1) from the treatment system influent; (2) from a location between the air strippers and carbon adsorption system; (3) from a location between the carbon adsorption vessels; and (4) from the treatment system effluent. One air sample would be collected from the exhaust of the vapor-phase canister on the air stripper. Each water sample would be analyzed for groundwater contaminants as specified in Table 9-35. Table 9-35 also presents USEPA analytical methods for the contaminants.

**9.4.3.2 Cost Estimate and Sensitivity Analysis.** For cost-estimating purposes, the following assumptions were made:

- IRM treatment facility would treat an average 500 gpm
- air stripping-carbon adsorption treatment facility rated for 2,000 gpm, but would treat an average 1,500 gpm
- six carbon vessel rebeds per year in IRM facility ($15,500 per rebed)

- three vapor-phase carbon canisters replaced every six years ($26,000 per replacement)
- $6,900 per month for leasing vapor-phase carbon canisters (3)
- three carbon vessel rebeds per year in Air Stripping - Carbon Adsorption treatment facility ($15,500 per rebed)
- spent carbon transported off site for thermal reactivation

The cost estimate for this alternative is shown in Table 9-38. Cost, material usage, and vendor information are provided in Appendices D.5, D.6, and D.7, respectively. Estimated remediation costs for this alternative are sensitive to a variation in the cost for carbon replacement in the IRM facility and new facility. Off-site transport and thermal reactivation of spent carbon is heavily regulated and changes in regulations over the life (i.e., 65 years) of the project could result in significant increases in operating costs for this alternative.

**9.4.3.3 Remedial Alternative Evaluation**. The assessment of this alternative using the evaluation criteria is presented in Table 9-39.

**9.4.4 Alternative PBG-GW5: IRM and Resin Adsorption**

This subsection describes the IRM and Resin Adsorption alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the nine evaluation criteria.

**9.4.4.1 Description**. The IRM and Resin Adsorption alternative consists of: (1) constructing the extraction system; (2) constructing a new resin adsorption treatment facility adjacent to the existing IRM treatment facility; (3) modifying the existing 10-inch diameter effluent pipe; (4) modifying the existing IRM treatment facility; and (5) pumping and treating groundwater in the IRM facility and the new facility to remove groundwater contaminants (i.e., CCL4, 24DNT, 26DNT, CHCL3, TRCLE, 111TCE, NNDPA, BE, CD, CR, HG, PB, MN, and SO4). Figure 9-27 shows the proposed locations of the extraction system, new treatment facility, and effluent pipe. The alternative would be designed to meet the remedial action objectives for groundwater. The key components of the alternative are:

- treatability testing
- site preparation and mobilization (see Subsection 9.4.2.1)
- extraction system construction (see Subsection 9.4.2.1)
- resin adsorption treatment facility construction
- effluent pipe modification (see Subsection 9.4.2.1)
- IRM facility modification (see Subsection 9.4.2.1)
- resin adsorption treatment facility operation
- IRM facility operation (see Subsection 9.4.2.1)
- treated groundwater discharge (see Subsection 9.4.2.1)
- groundwater monitoring (see Subsection 9.4.1.1)

Site preparation and mobilization, extraction system construction, effluent pipe modification, IRM facility modification, IRM facility operation, and treated groundwater discharge for this alternative would be similar to those discussed in Subsection 9.4.2.1. Groundwater monitoring for this alternative would be similar to that discussed in Subsection 9.4.1.1. The other key components are discussed in the following paragraphs.

The resin adsorption system described in the following paragraphs is marketed by Rohm and Haas Company. Similar systems may be marketed by other vendors. The Rohm and Haas system is described here only as an example of resin adsorption technology. The entire facility (i.e., extraction, treatment, and discharge) design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

Treatability Testing. Resin adsorption is considered an innovative technology for groundwater treatment. Groundwater remediation experience with the particular resin (i.e., "Ambersorb 563") recommended by the vendor (i.e., Rohm and Haas) is limited. Consequently, treatability studies are recommended.

Prior to treatability testing, up to five resins are selected for evaluation. Initially, static adsorption isotherms are performed on each resin. Based upon the results of the isotherm studies, one or two resins are selected for performing column studies. The column studies determine flow rate effects and regeneration efficiency. Upon completion of the column studies, a cost-performance analysis is performed. The cost-performance analysis considers operating costs over the lifetime of the project, capital investment costs, maintenance costs, and contaminant disposal costs.

Resin Adsorption Treatment Facility Construction. A permanent groundwater treatment facility would be constructed adjacent to the IRM facility (see Figure 9-27). The building would be a pre-engineered structure installed on a reinforced concrete pad. A sump would be built into the pad to collect spilled liquids and recirculate them back into the treatment system. Electrical service would be supplied to the treatment facility for lights, HVAC, and operation of the treatment systems. The maximum electrical load in the new facility is expected to be approximately 525 KW. Because the electrical service to the IRM facility is currently 192 KVA (i.e., 400A/480V/3-phase), additional service would have to be brought to the site. The nearest source that is capable of providing sufficient electricity to the treatment facility is a 12,470V three-phase power transmission line that passes approximately 200 feet from the IRM facility (Thurow, 1993). An electrical substation incorporating a 0.75 MVA transformer and associated switchgear would be constructed near the treatment facilities to step down the voltage for treatment system use.

Water would be supplied to the new facility for the steam generator and condenser, and for maintenance and cleaning activities. A 1-inch diameter branch line off the existing 3-inch diameter process water main (located approximately 150 feet from the IRM facility) would be constructed to the new facility.

A 6-inch diameter branch line off the IRM influent (i.e., influent from the source control wells) line would be constructed to the new facility. The branch line would allow treatment plant operators to divert flow from the source control wells to the new facility in the event the IRM treatment system fails or is shut down for maintenance. A 10-inch diameter pipe would be constructed from the new facility to the IRM facility for transport of effluent to the existing effluent pipe.

Equipment installed in the treatment facility would include an influent equalization tank, one average-flow (i.e., 1,500 gpm) influent transfer pump, one maximum-flow (i.e., 2,000 gpm) influent transfer pump, the resin adsorption system, an effluent tank, one average-flow effluent transfer pump, and one maximum-flow effluent transfer pump (Figure 9-30). The influent equalization tank would have a 5,000-gallon capacity (additional capacity would not be necessary because the pumping and treatment flows would typically be constant). The average-flow influent transfer pump would be rated for 1,500 gpm at a TDH of 300 feet (150 hp). The maximum-flow influent transfer pump would be rated for 2,000 gpm at a TDH of 510 feet (350 hp). The resin adsorption system would consist of a prefiltration system (i.e., bag filters), two resin adsorption service vessels, one steam generator, one condenser, one phase-separation vessel, and one superloading vessel (see

Figure 9-30). A resin column would be attached to the condenser for treatment of condenser vapor. The effluent tank would have a 5,000-gallon capacity. The average-flow effluent transfer pump would be rated for 1,500 gpm at a TDH of 325 feet (165 hp). The maximum-flow effluent transfer pump would be rated for 2,000 gpm at a TDH of 325 feet (220 hp). The flow (i.e., 2,000 gpm) and the TDH (i.e., 325 feet) in the effluent pipe would be constant regardless of whether it is combined flow from the IRM and the new facility or it is flow from the new facility alone.

Floor space required for the new treatment facility building was estimated using the following dimensions for treatment system equipment:

- Tanks. Tank diameter is assumed to be 12 feet for the influent equalization and effluent tanks.
- Influent Transfer Pumps. The foot print for the influent transfer pumps is estimated to be 8 by 10 feet.
- Resin Absorption System. The foot print for the resin adsorption system is estimated to be 20 by 35 feet.
- Effluent Transfer Pumps. The foot print for the effluent transfer pumps is estimated to be 8 by 10 feet.

Allowing for approximately 500 square feet for a office/control center and storage space, the floor space required for the building is estimated to be 2,700 square feet. For preliminary design and cost-estimating purposes, the building would occupy a foot print of 30 by 90 feet.

Resin Adsorption Treatment Facility Operation. New treatment facility operation would be dedicated to treatment of influent from the boundary control wells. The assumed contaminant concentrations in the influent from the boundary control wells and the estimated surface water discharge limits are presented in Table 9-33.

Operation of the new treatment facility would consist of pumping (with the extraction well pumps) contaminated groundwater to the influent equalization tank. The influent transfer pumps would pump water from the equalization tank through the prefiltration and resin adsorption systems to the effluent tank. The effluent transfer pump would pump water from the effluent tank through the effluent pipe to the

Wisconsin River (see Figure 9-30). To provide maximum efficiency during average-flow operation, the 1,500 gpm pumps would be used during routine treatment plant operation. To provide maximum efficiency during maximum-flow operation, the 2,000 gpm pumps would be used when flow from the source control wells is diverted to the new facility (i.e., during IRM facility shut down).

Routine operation and maintenance practices would include in situ regeneration of saturated resin in the lead resin vessel upon CHCL3 breakthrough (i.e., detectable concentrations of CHCL3 in the lead vessel effluent). Steam supplied by the on-site steam generator would be used for resin regeneration (see Figure 9-30). After the lead vessel is taken out service, steam would be forced through the resin bed where contaminants would be desorbed from the resin. The contaminants would be transported either in solution or in vapor phase to the condenser. From the condenser, steam and contaminant condensate would flow to the phase separation vessel where a concentrated organic phase and a saturated aqueous phase would form. An estimated 350 pounds of concentrated organics would be recovered each year (Plantz, 1993). The concentrated organics would be stored in a tank until it is transported off site for disposal or treatment. The saturated aqueous phase would be pumped to the superloading column where it would be treated with resin. Effluent from the superloading column would be recycled into the treatment system influent. After regeneration, the resin bed in the lead vessel would require two hours to cool prior to being placed back into service. The resin bed in the superloading column would also be regenerated using the same process.

During resin regeneration in the lead vessel, all of the treatment system flow would be diverted to the polishing vessel so that there is no interruption in treatment system operation. After resin regeneration in the lead vessel, the flow path through the resin vessels would be reversed by following a prescribed valve sequence so that the polishing vessel becomes the lead vessel and the lead vessel becomes the polishing vessel in the series configuration.

When the resin in the column used for treatment of condenser vapor is saturated, it would be replaced with virgin resin. Resin replacement would be an infrequent occurrence because the concentration of contaminants in the condenser vapor is not expected to be significant.

Using the assumed influent contaminant concentrations presented in Table 9-33 for input parameters, modeling of the rate of resin saturation indicates that resin regeneration would occur every 73 days of routine (i.e., 1,500 gpm) treatment system

operation (Plantz, 1993). Consequently, approximately five regenerations would be required per year.

Filter elements would be replaced when there is excessive pressure drop across the filters. During element replacement, treatment system flow would be diverted to the alternate filter in the filter assembly so that there is no interruption in treatment system operation.

For purposes of the FS, bi-weekly sampling and analysis would be required to monitor performance of the treatment system. One sample would be collected from each of the following three locations: (1) from the treatment system influent; (2) from an intermediate point between the resin vessels; and (3) from the treatment system effluent. One air sample would be collected from the vent on the column treating the condenser vapor. Each water sample would be analyzed for the contaminants specified in Table 9-35. Table 9-35 also presents USEPA analytical methods for the contaminants.

**9.4.4.2 Cost Estimate and Sensitivity Analysis.** For cost-estimating purposes, the following assumptions were made:

- IRM treatment facility would treat an average 500 gpm
- resin adsorption treatment facility rated for 2,000 gpm, but would treat an average 1,500 gpm
- six carbon vessel rebeds per year in IRM facility ($15,500 per rebed)
- 350 lbs of concentrated organics transported for off-site incineration each year

The cost estimate for this alternative is shown in Table 9-40. Cost, material usage, and vendor information are provided in Appendices D.5, D.6, and D.7, respectively. Other than for the cost of electricity, this alternative is not significantly sensitive to variations of assumed values.

**9.4.2.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 9-41.

### 9.4.5 Alternative PBG-GW7: IRM and UV Reduction - Carbon Adsorption

This subsection describes the IRM and UV Reduction - Carbon Adsorption alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the nine evaluation criteria.

**9.4.5.1 Description.** The IRM and UV Reduction - Carbon Adsorption alternative consists of: (1) constructing the extraction system; (2) constructing a new UV reduction - carbon adsorption treatment facility adjacent to the existing IRM treatment facility; (3) pumping and treating groundwater in the IRM facility and the new facility to remove groundwater contaminants (i.e., CCL4, 24DNT, 26DNT, CHCL3, TRCLE, 111TCE, NNDPA, BE, CD, CR, HG, PB, MN, and SO4); and (4) discharging the treated groundwater to Lake Wisconsin through the modified 10-inch diameter effluent pipe. Figure 9-27 shows the proposed locations of the extraction system, new treatment facility, and effluent pipe. The alternative would be designed to meet the remedial action objectives for groundwater. The key components of the alternative are:

- treatability testing
- site preparation and mobilization (see Subsection 9.4.2.1)
- extraction system construction (see Subsection 9.4.2.1)
- UV reduction - carbon adsorption treatment facility construction
- IRM facility modification (see Subsection 9.4.2.1)
- UV reduction - carbon adsorption treatment facility operation
- IRM facility operation (see Subsection 9.4.2.1)
- treated groundwater discharge (see Subsection 9.4.2.1)
- groundwater monitoring (see Subsection 9.4.1.1)

Site preparation and mobilization, extraction system construction, IRM facility modification, IRM facility operation, and treated groundwater discharge for this alternative would be similar to those discussed in Subsection 9.4.2.1. Groundwater monitoring for this alternative would be similar to that discussed in Subsection 9.4.1.1. The other key components are discussed in the following paragraphs.

The UV/reduction system described in the following paragraphs is designed, constructed, and marketed by Solarchem Environmental Systems (Solarchem). Similar systems may be marketed by other vendors. The Solarchem system is described here only as an example of UV/reduction technology. The entire

treatment facility design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

Treatability Testing. UV reduction is considered an innovative technology for groundwater treatment. Although preparations for start up of a full-scale UV reduction system constructed for NASA at the Kennedy Space Center are underway, groundwater remediation experience with UV reduction is currently limited to pilot testing of the technology (Nolan, 1993). Consequently, treatability studies are recommended.

Treatability tests are conducted at the Solarchem facility in Markham, Ontario. One 55-gallon drum of Propellant Burning Ground groundwater would be shipped to the facility for testing. Four or five tests with different doses of the vendor's proprietary reagent are conducted using bench-scale equipment. While the tests would not determine the optimum dose of UV light and reagents for treatment of groundwater, they would provide information on the number of UV reactors (and associated capital costs) required for groundwater treatment and treatment cost per 1,000 gallons (Nolan, 1993). Additional studies can be conducted in order to further define treatment requirements and costs.

UV Reduction - Carbon Adsorption Treatment Facility Construction. A permanent groundwater treatment facility would be constructed adjacent to the IRM facility (see Figure 9-27). The building would be a pre-engineered structure installed on a reinforced concrete pad. A sump would be built into the pad to collect spilled liquids and recirculate them back into the treatment system. Electrical service would be supplied to the treatment facility for lights, HVAC, and operation of the treatment systems. The maximum electrical load in the new facility is expected to be approximately 1,100 KW. The electrical load from the UV lamps alone is 650 KW of 480V three-phase power (Nolan, 1993). Because the electrical service to the IRM facility is currently 192 KVA (i.e., 400A/480V/3-phase), additional service would have to be brought to the site. The nearest source that is capable of providing sufficient electricity to the treatment facility is a 12,470V three-phase power transmission line that passes approximately 200 feet from the IRM facility (Thurow, 1993). An electrical substation incorporating a 1.5 MVA transformer and associated switchgear would be constructed near the treatment facilities to step down the voltage for treatment system use.

Water would be supplied to the new facility for maintenance and cleaning activities. A branch line off the existing water line to the IRM facility would be constructed to the new facility for that purpose.

A 6-inch diameter branch line off the IRM influent (i.e., influent from the source control wells) line would be constructed to the new facility. The branch line would allow treatment plant operators to divert flow from the source control wells to the new facility in the event the IRM treatment system fails or is shut down for maintenance and/or modification. A 10-inch diameter pipe would be constructed from the new facility to the IRM facility for transport of effluent to the existing effluent pipe.

Equipment installed in the treatment facility would include a filter assembly, an influent equalization tank, one average-flow (i.e., 1,500 gpm) influent transfer pump, one maximum-flow (i.e., 2,000 gpm) influent transfer pump, the UV reduction system, the carbon adsorption system, an effluent tank, one average-flow effluent transfer pump, and one maximum-flow effluent transfer pump (Figure 9-31). The filter assembly would consist of two parallel filters, each filter containing 12 filter bags and rated for 2,000 gpm maximum flow. The influent equalization tank would have a 5,000-gallon capacity (additional capacity would not be necessary because the pumping and treatment flows would typically be constant).

The average-flow influent transfer pump would be rated for 1,500 gpm at a TDH of 55 feet (35 hp). The maximum-flow influent transfer pump would be rated for 2,000 gpm at a TDH of 95 feet (80 hp). The UV reduction system would consist of four parallel trains of one 4x30 KW and one 3x30 KW standard reactor skids as shown in Figure 9-31. Auxiliary equipment for the UV reduction system would include an additive feed system for the UV reactors. The additive would be stored in a 5,000 gallon tank, which is sufficient capacity for 10 days of UV reduction system operation (Nolan, 1993). The carbon adsorption system would consist of three parallel trains of 2x20,000 lb. skid-mounted carbon vessels (see Figure 9-31). Each carbon vessel would have a diameter of 10 feet.

The effluent tank would have a 5,000 gallon capacity. The average-flow effluent transfer pump would be rated for 1,500 gpm at a TDH of 325 feet (165 hp). The maximum-flow effluent transfer pump would be rated for 2,000 gpm at a TDH of 325 feet (220 hp). The flow (i.e., 2,000 gpm) and the TDH (i.e., 325 feet) in the effluent pipe would be constant regardless of whether it is combined flow from the IRM and the new facility or is flow from the new facility alone.

Floor space required for the new treatment facility building was estimated using the following dimensions for treatment system equipment:

- Filter Assembly. The foot print of the filter assembly is estimated to be 8 by 12 feet.
- Tanks. Tank diameter is assumed to be 12 feet for the influent equalization, additive storage, and effluent tanks.
- Influent Transfer Pumps. The foot print of the influent transfer pumps is estimated to be 6 by 8 feet.
- UV Reduction System. Skid dimensions are 3 by 8 feet for the 3x30 KW skids and 3 by 11 feet for the 4x30 KW skids.
- Carbon Adsorption System. Skid dimensions are 12 by 25 feet for each 2x20,000 lb. carbon vessel skids.
- Effluent Transfer Pumps. The foot print of the effluent transfer pumps is estimated to be 8 by 10 feet.

Allowing for approximately 500 square feet for a office/control center and storage space, the floor space required for the building is estimated to be 4,500 square feet. For preliminary design and cost-estimating purposes, the building would occupy a foot print of 50 by 90 feet.

<u>UV Reduction - Carbon Adsorption Treatment Facility Operation</u>. New treatment facility operation would be dedicated to treatment of influent from the boundary control wells. The assumed contaminant concentrations in the influent from the boundary control wells and the estimated surface water discharge limits are presented in Table 9-33.

Operation of the new treatment facility would consist of pumping (with the extraction well pumps) contaminated groundwater through the filter assembly and into the influent equalization tank. The influent transfer pump would pump water from the equalization tank through the UV reduction and carbon adsorption systems to the effluent tank. The effluent transfer pump would pump water from the effluent tank through the effluent pipe to the Wisconsin River. To provide maximum efficiency during average-flow operation, the 1,500 gpm pumps would be used during routine

treatment plant operation. To provide maximum efficiency during maximum-flow operation, the 2,000 gpm pumps would be used when flow from the source control wells is diverted to the new facility (i.e., during IRM facility shut down).

Routine operation and maintenance practices would include replacement of UV lamps. One person for one eight-hour shift every four months would be required for lamp changes. Otherwise, only daily monitoring is required.

Removal of 24DNT, 26DNT, and NNDPA would occur in the aqueous-phase carbon adsorption system. Routine operating and maintenance practices would include replacement of spent carbon in the lead carbon vessels upon breakthrough (i.e., detectable concentrations of a contaminant in the lead vessel effluent). During carbon replacement in the lead vessels, all of the treatment system flow would be diverted to the polishing vessel so that there is no interruption in treatment system operation. After carbon replacement in the lead vessel, the flow path through the carbon vessels would be switched by following a prescribed valve sequence so that the polishing vessel becomes the lead vessel and the lead vessel becomes the polishing vessel in the series configuration.

Using the assumed influent 24DNT and 26DNT concentrations presented in Table 9-33 for input parameters, modeling of the rate of aqueous-phase carbon saturation at 500 gpm indicates that breakthrough in each lead vessel would occur approximately every 50 years of new treatment system operation (Rogers, 1993b). Consequently, approximately three rebeds would be required over the 65-year project life of the project (i.e., one rebed per lead vessel multiplied by three carbon vessels). The modeled rate of aqueous-phase carbon saturation assumes the use of virgin carbon for rebed material. Virgin carbon has a higher capacity for adsorbed contaminants than reactivated carbon.

Filter bags would be replaced when there is excessive pressure drop across the filter assembly. During filter bag replacement, treatment system flow would be diverted to the alternate filter so that there is no interruption in treatment system operation.

For purposes of the FS, bi-weekly sampling and analysis would be required to monitor performance of the treatment system. One sample would be collected from each of the following four locations: (1) from the treatment system influent; (2) from a location between the UV reduction system and the carbon adsorption system; (3) from a location between the carbon adsorption vessels; and (4) from the treatment system effluent. Each water sample would be analyzed for groundwater

contaminants as specified in Table 9-35. Table 9-35 also presents USEPA analytical methods for the contaminants.

**9.4.5.2 Cost Estimate and Sensitivity Analysis.** For cost-estimating purposes, the following assumptions were made:

- IRM treatment facility would treat an average 500 gpm
- UV/reduction treatment facility rated for 2,000 gpm, but would treat an average 1,500 gpm
- six carbon vessel rebeds per year in IRM facility ($15,500 per rebed)
- three carbon vessel rebeds over the life of the project (i.e., 65 years) in the UV/reduction carbon adsorption facility

The cost estimate for this alternative is shown in Table 9-42. Cost, material usage, and vendor information are provided in Appendices D.5, D.6, and D.7, respectively. Other than for the cost of electricity, this alternative is not significantly sensitive to variations of assumed values.

**9.4.5.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 9-43.

### 9.4.6 Comparative Analysis of Alternatives

This subsection compares the relative advantages and disadvantages of the groundwater alternatives using the evaluation criteria. A comparative summary is provided in Table 9-44.

**9.4.6.1 Overall Protection of Human Health and the Environment.** All of the groundwater remedial alternatives, except PBG-GW1 (i.e., Minimal Action) achieve remedial action objectives. PBG-GW1 would result in continued exceedances of federal and state drinking water standards.

**9.4.6.2 Compliance with ARARs.** All of the groundwater remedial alternatives, except PBG-GW1, would comply with ARARs pertinent to on-site and off-site activities. Alternatives PBG-GW2 and PBG-GW4 have significantly greater exposure

to changing regulations than PBG-GW5 and PBG-GW7 because of the large volume of spent carbon that is shipped off site for thermal reactivation.

**9.4.6.3 Long-term Effectiveness and Permanence.** Because source remediation (i.e., waste pits in the Contaminated Waste Area) is beyond the scope of the groundwater remedial alternatives, and the source may continue to leach contaminants to groundwater for an indefinite period, inherent residual risk is associated with each of the alternatives. However, total remediation of waste pit soils is proposed (see Subsection 9.3.7) and total groundwater remediation could be achieved.

**9.4.6.4 Reduction in Toxicity, Mobility, and Volume through Treatment.** Except for PBG-GW1, each of the groundwater remedial alternatives would result in destruction of groundwater contaminants. Off-site thermal activation of spent carbon is included in all of the treatment alternatives, but to a lesser degree in Alternatives PBG-GW5 and PBG-GW7. The only alternative that includes on-site destruction of groundwater contaminants is PBG-GW7.

**9.4.6.5 Short-Term Effectiveness.** No adverse impacts to the community would be experienced during implementation of any of the groundwater remedial alternatives. However, adverse impacts to the environment may be experienced during construction of the extraction system for Alternatives PBG-GW2, PBG-GW4, PBG-GW5, and PBG-GW7.

**9.4.6.6 Implementability.** No implementability concerns are associated with Alternatives PBG-GW1, PBG-GW2, and PBG-GW4. Alternatives PBG-GW5 and PBG-GW7 include developing technologies and both alternatives would require treatability studies. However, PBG-GW7 uses existing equipment (i.e., UV/oxidation equipment) proven in full-scale treatment facilities and is further developed than the technology (i.e., resin adsorption) included in PBG-GW5.

**9.4.6.7 Cost.** Alternative PBG-GW1 has the lowest capital cost (i.e., $10,000) and the lowest present worth operation and maintenance cost (i.e., $7,432,000) compared to the other alternatives. Of the alternatives that include groundwater extraction and treatment (i.e., Alternatives PBG-GW2, PBG-GW4, PBG-GW5, and PBG-GW7), Alternative PBG-GW5 has the highest capital cost (i.e., $9,047,000) but the lowest present worth operation and maintenance cost (i.e., $26,517,000). Alternatives PBG-GW2 and PBG-GW4 have similar capital costs (i.e., $6,569,000 and $7,303,000, respectively) and similar present worth operation and maintenance costs (i.e., $28,471,000 and $28,260,000, respectively). Alternative PBG-GW7 has a

relatively high capital cost (i.e., $8,446,000) and the highest present worth operation and maintenance cost (i.e., $31,623,000) compared to the other alternatives.

### 9.4.7 Selection of Preferred Alternative

Alternative PBG-GW4 (i.e., IRM and Air Stripping - Carbon Adsorption) would achieve remedial action objectives and is the preferred alternative for groundwater remediation at the Propellant Burning Ground. Although PBG-GW4 would generate a secondary waste stream greater than that of the two alternatives (i.e., PBG-GW5 and PBG-GW7) that include innovative treatment technologies (i.e., resin adsorption and UV reduction, respectively), PBG-WP4 treatment technologies (i.e., air stripping and carbon adsorption) are proven technologies that have equivalent or lower capital and operating costs than those of resin adsorption and UV reduction. Additionally, design work on PBG-GW4 could begin immediately and has a higher probability of meeting the proposed design and construction schedule than PBG-GW5 and PBG-GW7, which require treatability studies prior to design.

Present worth of PBG-GW4 (i.e., $35,563,000) is slightly higher than that of GW-2 (i.e., $35,040,000), but it has lower exposure to increasing costs resulting from changing ARARs that affect transportation and off-site treatment of hazardous wastes. PBG-GW2 would annually generate 360,000 lbs of spent carbon for off-site thermal reactivation, while PBG-GW4 would annually generate 186,000 lbs of spent carbon. Consequently, increasing unit costs for off-site reactivation of spent carbon would have a lower impact on PBG-GW4.

To ensure that the calcium carbonate incrustation that is presently occurring in the IRM facility does not reoccur in the Air Stripping - Carbon Adsorption facility, testing should be conducted in the IRM facility to determine the effectiveness of pH adjustment for reducing calcium carbonate precipitation.

# 10.0 DETAILED ANALYSIS OF DETERRENT BURNING GROUND ALTERNATIVES

Remedial alternatives for subsurface soil and groundwater remediation at the Deterrent Burning Ground are evaluated in this section using seven of the nine evaluation criteria recommended in USEPA's RI/FS guidance (USEPA, 1988). These criteria serve as the basis for the detailed analysis. The criteria are described in Subsection 1.7. The alternatives that are evaluated in this section were retained after initial screening of alternatives in Section 4.0.

This section presents a detailed evaluation of each of the remedial alternatives for both of the contaminated media by comparing the relative advantages and disadvantages of each alternative using the evaluation criteria. Following alternative comparison, the recommended remedial alternative for subsurface soil and groundwater are chosen. The recommended remedial alternatives are presented at the conclusion of each media-specific subsection.

## 10.1 SUBSURFACE SOIL ALTERNATIVES

The following soil alternatives were retained after the development and initial screening in the Section 4.0:

- Minimal Action (DBG-SB1)
- Capping (DBG-SB2)
- Soil Washing (DBG-SB4)
- On-site Incineration (DBG-SB7)
- Composting (DBG-SB8)

Minimal Action was retained because it will serve as a baseline for the other surface soil alternatives. Capping will reduce exposure and protect groundwater from contamination due to infiltration. Soil Washing is designed to concentrate contaminants to a fraction of their original volume and dispose of the concentrated fraction off site. On-site incineration is designed to treat soil by incineration leaving only a small volume of fly ash to dispose of off-site. Composting is designed to biodegrade contaminants. The treated soil is replaced in the excavations. These remedial alternatives are described and evaluated in detail in the following subsections.

### 10.1.1 Alternative DBG-SB1: Minimal Action

This subsection describes the minimal action alternative, provides a cost estimate, and evaluates the alternative using the seven evaluation criteria.

**10.1.1.1 Description.** The minimal action alternative is developed to assess impacts on human health and the environment if no remedial actions are implemented. Components of this alternative are as follows:

- posted warning signs
- institutional controls
- educational programs, including public meetings and presentations
- groundwater monitoring program with five-year site reviews

The key components of this alternative are discussed in the following paragraphs.

Warning Signs. Warning signs would be posted along the perimeter of the deterrent burning pits.

Institutional Controls. At the present, the Army has no plans to designate the area within BAAP for residential or public use. This component of the minimal action alternative is included only for consideration in the event the Army should decommission the site and return it to the public. Institutional controls in the form of deed or zoning restrictions will be implemented as necessary to restrict residential or public use of the site. The legal ramifications associated with instituting property deed restrictions will be coordinated with appropriate Army officials, WDNR, and the City of Baraboo.

Educational Programs. This component includes conducting public meetings and presentations to keep the public informed of the site status. Site status refers to both the general condition of the site and remaining contaminant levels.

Monitoring Program. Under CERCLA 121c, remedial action that results in hazardous substances, pollutants, or contaminants remaining on site must be reviewed at least every five years. Data collected during the monitoring program aids in determining whether human health is protected. This review may initiate remedial action, if appropriate.

The monitoring program would be implemented to determine the existing levels of contaminants and evaluate the potential migration of subsurface soil contaminants from the Deterrent Burning Ground soils to groundwater.

The groundwater monitoring program to be implemented would be a continuation of the ongoing monitoring program defined in the October 30, 1992 "Modification of Conditional Plan Approval of In-field Conditions Report" (WDNR, 1992) attached in Appendix D.1. The purpose of this BAAP-wide sampling and analyses program is to monitor contamination migration and assess future environmental impacts. The monitoring locations, analytical parameters, and monitoring frequency pertinent to the Deterrent Burning Ground are presented in Table 10-1. One additional monitoring well, DBM-82-02, has been added to the current program.

**10.1.1.2 Cost Estimate**. Operating costs for the minimal action alternative include maintenance and groundwater monitoring. The cost estimate is presented in Table 10-2. Note: Although groundwater monitoring and five-year site reviews are a required component of this alternative, their costs are included with the groundwater remedial alternatives estimate (see subsection 10.2.1.1).

**10.1.1.3 Alternative Evaluation**. The assessment of this alternative using the evaluation criteria is presented in Table 10-3.

### 10.1.2 Alternative DBG-SB2: Capping

This subsection describes the capping alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the seven evaluation criteria.

**10.1.2.1 Description**. The capping alternative consists of constructing a RCRA cap over the DBG. Figure 10-2 shows the approximate locations of the RCRA cap. Key components of the alternative are:

- site preparation and mobilization
- contaminated soil delineation
- cap construction (see also Subsection 9.2.2.1)
- post-closure maintenance (see also Subsection 9.2.2.1)
- institutional controls (see Subsection 10.1.1.1)
- groundwater monitoring (see Subsection 10.2.1.1)
- five-year site reviews (see Subsection 10.2.1.1)

Cap construction and post-closure maintenance are similar to the same alternative discussed in Subsection 9.2.2.1 for the PBG. Institutional controls for this alternative would be similar to that discussed in Subsection 10.1.1.1. However, institutional controls would have the added purpose of protecting the soil cover from invasive activities. Groundwater monitoring and five-year site reviews for this alternative would be similar to those discussed in Subsection 10.2.1.1. Other key components are discussed in the following paragraphs. The conceptual design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

Site Preparation and Mobilization. A 1.0 acre stockpile area for cap materials (i.e., clay, drainage sand, common borrow, and topsoil) would be established in the southwest portion of the Deterrent Burning Ground (see Figure 10-2). The area would be large enough to provide sufficient volume for several days of cap construction in the event delivery from the sources is interrupted. A parking area for heavy equipment and a construction-support trailer, would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot (see Figure 10-3). The parking area would also accommodate a mobile laboratory.

Equipment mobilized to the site would include earth-moving equipment (i.e., front-end loaders and bulldozers), dumptrucks, construction-support trailers, and a mobile laboratory.

Contaminated Soil Delineation. Only one subsurface soil sample has been taken in each of the burn pits and, therefore, extent of contamination must be field determined prior to cap design. An approximate contamination boundary is shown in Figure 10-1. The areas requiring remediation will be horizontally delineated using the RG for 24DNT (i.e., 4.29 mg/kg) as the contamination boundary with confirmation that previously detected contaminants meet respective RGs. Delineation would be conducted using a subsurface sampling device (e.g., split-spoons). A mobile laboratory will be equipped with a gas chromatograph for field screening of 24DNT.

Cap Construction. A multilayered cap that meets USEPA's guidance criteria for hazardous waste cover systems would be installed over the Deterrent Burning Ground Pits. The cap would cover approximately 1 acre. Figure 9-7 shows a typical cap construction cross-section. The cap would be constructed of the following materials (from the bottom up):

- compacted clay layer
- 60-mil flexible membrane liner
- sand drainage layer
- filter fabric
- compacted common borrow layer
- topsoil layer

After an appropriate base grade has been established, a 2-foot layer of clay, compacted to achieve a hydraulic conductivity of $1x10^{-7}$ cm/sec or less, would be placed over the area. Following placement of the clay layer, a 60-mil flexible membrane liner would be placed over the entire clay layer and anchored into the existing soil at the perimeter of the clay layer. A 1-foot layer of drainage sand would be placed over the flexible membrane liner. The permeability of the drainage layer would be $5x10^{-3}$ cm/sec or greater. Filter fabric would be placed over the drainage sand to prevent the migration of fines from the common borrow and topsoil layers into the drainage layer. A 2-foot layer of common borrow would be placed and compacted over the filter fabric. The 2-foot layer of common borrow, in conjunction with the 1-foot topsoil layer, would provide protection against frost penetration. The topsoil layer would be fertilized and seeded to provide a good vegetative cover. The cap would taper on all sides with an average slope of 5:1 (see Figure 9-7).

<u>Post-Closure Maintenance</u>. Post-closure maintenance would include annual inspections and, if necessary, performing cap repair. Repairs would be required if the caps have been damaged by burrowing animals, vehicular traffic, or loss of vegetation. Cap vegetation would be mowed on an annual basis to prevent trees from taking root and damaging the caps.

**10.1.2.2 Cost Estimate.** For cost-estimating purposes, the following assumptions were made:

- 1 acre stockpile area for cap materials
- 0.25-acre parking area at each location
- 1 acre cap
- 8 hour annual visual inspection
- $10,000 for institutional controls

NOTE: Although groundwater monitoring and five-year site reviews are required components of this alternative, their costs are included in the groundwater remedial alternative estimates (see Subsection 10.2)

The cost estimate for this alternative is shown in Table 10-4. Cost and material usage information are provided in Appendices E.1 and E.2, respectively.

### 10.1.3 Alternative DBG-SB4: Soil Washing

This subsection describes the soil washing alternative, provides a cost estimate for the alternative, and evaluates the alternative using the seven evaluation criteria. The treatment of soils by soil washing is expected to be complete within a year.

**10.1.3.1 Description.** The soil washing alternative consists of removing and treating subsurface soils at the Deterrent Burning Ground where concentrations of 24DNT exceed RG concentrations. The approximate extent of contamination is shown in Figure 10-1. This alternative is designed to meet the remedial action objective for subsurface soil. The key components of the alternative are:

- treatability testing
- site preparation and mobilization
- contaminated soil delineation
- excavation of contaminated soil
- soil washing
- treatment of secondary wastes
- backfill excavations

A RCRA permit may be required for this alternative (and others). The key components are discussed in the following paragraphs:

Treatability Testing. Representative samples will be collected to determine, through a sieve analysis, the percentage finer curve and the contamination per fraction. Bench-scale investigations will be conducted to aid in the selection of treatment units and to determine the surfactant, polymer, flow rate, and throughput requirements.

Site Preparation and Mobilization. Contaminated soil will be stockpiled in a 1 acre area established in the southwest portion of the Deterrent Burning Ground (Figure 10-3). The area will be large enough to accommodate 5,700 cubic yards of contaminated soil (the estimated volume). Because the excavated soil is potentially a RCRA hazardous waste (i.e., potentially failing the TCLP test for 24DNT), the untreated stockpile area will be designed and constructed to meet regulatory requirements for temporary storage of hazardous waste. A 1.75-acre area will be prepared by grubbing, grading, and placing a 1-foot gravel base to accommodate the

mobile treatment unit, mobile laboratory, construction-support trailers, and heavy equipment.

A concrete decontamination pad would be constructed near the construction-support trailers. The pad would be used to decontaminate equipment used in the excavation and handling operations before the equipment can leave the exclusion zone. The pad would be designed to collect contaminated water in a sump and pump it into a collection/storage tank for disposal.

Equipment to be mobilized to the site include the mobile treatment unit, construction-support trailers (including a trailer for the mobile laboratory), earth-moving equipment (e.g., backhoes, front-end loaders), and dump trucks.

Contaminated Soil Delineation. Only one subsurface soil sample has been taken in each of the burn pits and, therefore, extent of contamination must be field determined prior to excavation. An approximate contamination boundary is shown in Figure 10-1. The areas requiring remediation will be horizontally delineated using the RGs for 24DNT (i.e., 4.29 mg/kg) as the contamination boundary with confirmation that previously detected contaminants meet respective RGs. Delineation will be conducted using subsurface sampling equipment. The vertical contamination boundary will be delineated by sampling through the center of each of the burning pits. The risk associated with the subsurface soils at the Deterrent Burning Ground is for a construction worker doing intrusive work. The excavations at DBB-91-01 and DBB-91-03 would be approximately 28 and 22 feet deep, respectively and at DBB-91-02 the excavation would be approximately 8 feet. A mobile laboratory will be equipped with a gas chromatograph for field screening of 24DNT.

Excavation of Contaminated Soil. Contaminated soil would be excavated from the burn pits using backhoes. The excavations would be sloped in accordance with the Occupational Safety and Health Administration requirements. Dedicated (used exclusively for this project, then decontaminated) dump trucks would transport the soil to the hazardous soil stockpile area.

During excavation activities, an exclusion zone would be established to encompass the burn pits and the stockpile area. Excavation and handling equipment can operate within this zone and shall not leave without first undergoing decontamination.

Soil Washing. Figure 10-4 shows the flow diagram for the soil washing treatment system. The first step in soil washing involves separating the soil fractions using various mechanical screening techniques and hydrocyclones. Based on the fact that there is a relationship between particle size and contaminant residence (contaminants generally are not bound to the oversize fraction), the gross oversize (>8") and the oversize (>2" but <8") materials would either be recycled or returned to the excavations (provided smaller particles with potentially contaminated materials were removed from the surface). A wet screen is used on material <2" where pea-sized gravel drops out and the rest of the material forms a slurry that is pumped to the next phase of separation (hydrocyclones). The coarse-grained sands (generally >40-60 microns but < 2") are centrifuged to the bottom, while the fine-grained materials (generally <40-60 microns) and the water separates to the top of the unit.

The coarse-grained materials would be treated using long, rectangular air flotation tanks that use mechanical aerators and diffused air. A selected surfactant (from the treatability test) would be used in these units to reduce the surface tension between the contaminant and the soil mass and separate the two fractions. The contaminant fraction forms a froth on the surface that is removed and concentrated to be disposed of off site. The "clean" sand would be dewatered, sampled, and returned to the excavations.

The fine-grained materials and water from the hydrocyclones are pumped to the sludge management system. In the simplest case of treatment for fines, the slurry will be dosed with the polymer selected from the bench-scale tests and treated in the Lamella clarifier. The clarified solids would be thickened then dewatered using a belt filter press. The clarifier liquid is recycled.

Treatment of Secondary Waste. A dry filter cake is produced from the filter press which contains the concentrated contaminants. The filter cake and decontamination fluids would be disposed of off site. Water from dewatering operations would be returned to the wet screening area for reuse.

As an alternative to disposal of filter cakes in the disposal facility, if soil washing with composting of residuals is chosen at the Waste Pits then it is recommended that residuals from this soil washing operation be brought to the Propellant Burning Ground for composting.

Backfill Excavations. As much as practicable, clean sands would be returned to fill the excavations. An estimated 90 percent of the original 5,700 c.y. would be returned

to the excavations with the remaining 10 percent coming from an off-site borrow source. Material from the off-site borrow source would be placed on top of the treated soils.

**10.1.3.2 Cost Estimate.** For cost-estimating purposes, the following assumptions were made:

- 1 acre hazardous waste stockpile area
- 1.5 acre treatment area
- 0.25 acre parking area
- one concrete decontamination pad
- 5,700 cubic yards of contaminated soil
- 285 cubic yards of the contaminated soil is fine-grained
- costs of secondary waste treatment are included in overall treatment costs
- three-phase power is not available
- 30 borings (10 per burn pit) for 24DNT delineation
- treatability studies will be $25,000
- $250 per cubic yard for soil washing

The cost estimate for this alternative is shown in Table 10-6. Cost, material usage, and vendor information are provided in Appendices E.1, E.2, and E.3, respectively.

**10.1.3.3 Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 10-7. Soil washing has the potential for meeting the remedial action objective for subsurface soils at the Deterrent Burning Ground.

### 10.1.4 Alternative DBG-SB7: On-Site Incineration

This subsection describes the on-site incineration alternative, provides a cost estimate for the alternative, and evaluates the alternative using the seven evaluation criteria. This alternative would only be implemented if on-site incineration is the chosen alternative for subsurface soils in the Waste Pits (see Subsection 9.3.2.1), where an on-site incinerator would already be mobilized. Treatment of soils by incineration is expected to be complete within a year.

**10.1.4.1 Description.** The on-site incineration alternative consists of excavating 24DNT-contaminated soil, transporting it to the on-site incinerator at the Propellant

Burning Ground, and backfilling the excavations with treated soil and borrow material. The alternative would be designed to meet the remedial action objective for subsurface soil. The key components of the alternative are:

- site preparation and mobilization
- contaminated soil delineation (see Subsection 10.1.2.1)
- excavation of contaminated soil (see Subsection 10.1.2.1)
- transportation of contaminated soil
- screening and blending of contaminated soil (see Subsection 9.3.2.1)
- incineration of contaminated soil (see Subsection 9.3.2.1)
- transportation of secondary waste streams off site (see Subsection 9.3.2.1)
- backfilling excavations

A RCRA permit may be required for this alternative (and others). Contaminated soil delineation and excavation are similar to those discussed in Subsection 10.1.2.1. Screening and blending operations would be conducted on the combined soils from both the Deterrent Burning Ground and the Propellant Burning Ground. The discussion of soil screening and blending is similar to that discussed in Subsection 9.3.2.1. Incineration of contaminated soil and transportation of secondary waste streams are similar to those discussed in Subsection 9.3.2.1. The other key components are discussed in the following paragraphs.

Site Preparation and Mobilization. A 0.5-acre parking area for a mobile laboratory, construction-support trailers, and heavy equipment would be prepared by grubbing, grading, and placing a 1-foot gravel base. The parking area would be located in the southwest portion of the Deterrent Burning Ground (Figure 10-5).

A concrete decontamination pad would be constructed near the construction-support trailers. The pad would be used to decontaminate equipment used in the excavation and handling operations before the equipment can leave the exclusion zone. The pad would be designed to collect contaminated water in a sump and pump it into a collection/storage tank for disposal.

Equipment mobilized to the site would include construction-support trailers (including a trailer for the mobile laboratory), earth-moving equipment (e.g., backhoes, front-end loaders), and dumptrucks.

Transportation of Contaminated Soil. The contaminated soil excavated from the burning pits would be transported in lined and covered dumptrucks to the untreated soil stockpile area at the incinerator facility. The incinerator facility would be located at the Propellant Burning Ground.

Backfilling Excavations. As much as practicable, treated soils will be returned to fill the excavations. An estimated 90 percent of the original 5,700 cubic yards will be returned to the excavations with the remaining 10 percent coming from an off-site borrow source.

**10.1.4.2 Cost Estimate.** For cost- estimating purposes, the following assumptions were made:

- 0.5-acre parking area
- one concrete decon pad
- 5,700 cubic yards of 24DNT-contaminated soil
- 570 cubic yards of fly ash for off-site disposal
- 108-mile one-way trip to off-site landfill (Menomonee Falls, WI)
- $4.75 per loaded mile
- $100 per trip unloading fee
- $142.50 per ton for fly ash treatment (S/S) and disposal
- 30 borings (10 per burn pit) for 24DNT delineation
- $200 per ton for incineration at PBG
- transportation across site is $10 per load

The cost estimate for this alternative is shown in Table 10-8. Cost and material usage are provided in Appendices E.1 and E.2, respectively.

**10.1.4.3 Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 10-9. On-site incineration is a proven technology for 24DNT-contaminated soils and therefore this alternative has the potential for meeting the remedial action objective for subsurface soils at the Deterrent Burning Ground.

### 10.1.5 Alternative DBG-SB8: Composting

This subsection describes the composting alternative, provides a cost estimate, and evaluates the alternative using the seven evaluation criteria. Treatment of soils by composting is expected to be complete within two years.

**10.1.5.1 Description.** The composting alternative consists of: (1) excavating soils at the Deterrent Burning Ground where concentrations of 24DNT exceed RG concentrations in Pits 1, 2, and 3; and (2) composting the contaminated soil on site. The estimated extent of contamination is shown in Figure 10-1. This alternative would be designed to meet the remedial action objective for subsurface soil. The key components of the alternative are:

- site preparation and mobilization
- contaminated soil delineation (see Subsection 10.1.2.1)
- excavation of contaminated soil (see Subsection 10.1.2.1)
- screening, blending, and compost preparation
- composting contaminated soil
- backfilling excavations (see Subsection 10.1.4.1)

Site preparation and mobilization, transportation of contaminated soil, and backfilling excavations are similar to those discussed in Subsection 10.1.4.1. Contaminated soil delineation and excavation of contaminated soil are similar to those discussed in Subsection 10.1.2.1. The other key components are discussed in the following paragraphs.

Composting can be implemented by three methods: (1) static pile, (2) windrows, and (3) mechanically agitated in-vessel. Based on pilot tests conducted at a similar U.S. Army site (R.F. Weston Inc., 1992), windrow composting has been selected for this site. Windrow consists of a soil pile generally constructed in rows that are turned periodically to facilitate the microbial processes of composting.

The conceptual process description of the composting system addresses the system components and operations required to complete remediation. Figure 9-9 presents a schematic flow of operations for the composting system. The details included in the process description might be refined during remedial design, but the basic processing operations will remain the same.

Site Preparation and Mobilization. The composting site will be located in the Deterrent Burning Ground area as shown in Figure 10-6. The site will require approximately 5 acres to provide adequate room for vehicle access and maneuvering; storage areas for contaminated soil, amendment, and treated soil; a mixing area, and the windrow pad. In addition, an access road will be required to connect existing roads to the composting area.

The untreated soil excavated from the waste pits would be stockpiled in a bermed and lined staging area. The estimated quantity of contaminated soil to be treated is approximately 10,000 tons. The staging area is approximately 0.50 acre designed to stockpile at one time about half of the total quantity of soil to be treated. The remaining half of untreated soil will be excavated and staged after the initial quantity has been prepared and placed in the composting area. Adjacent to the untreated soil stockpile is the area for screening of soil and blending of amendment prior to composting. This area is approximately 0.25 acre, allowing for a three-day stockpile of amendment and area for blending and mixing of the amendment with the soil.
The soil prepared for composting would be placed as windrows on an asphalt foundation pad inside four structures. Two windrows will be located in each structure, which is 88 feet wide and 200 feet long. With allowances for room to maneuver the mechanical windrow turner between the structures and around the perimeter, the total area required for the windrow composting structures is approximately 3 acres.

The treated compost stockpile area will be an unlined area with a gravel bed. Adequate storage capacity will be provided to allow for flexibility in materials handling and to accommodate the analytical turnaround for performance verification sampling. The area required will be approximately 0.75 acre, assuming that the volume of the final compost is approximately twice the volume of the initial soil added (the amendment compacts during composting).

Additional graded and graveled areas are needed for storage of borrow soil for cap construction, vehicle access, administrative and personnel facilities, maintenance areas, and the on-site portable laboratory. The additional area required is assumed to be approximately one acre.

Based on the above, the total area requirement for the 10,000-ton composting facility is approximately five acres. In addition to these areas, access roads will be required to connect the treatment area with existing roads.

Screening, Blending, and Compost Preparation. The contaminated soil will be excavated from the waste pits and stockpiled in the untreated soil area. Large rocks and debris would need to be removed from the soil prior to composting to avoid undue stress or damage to the windrow turner equipment. The need for and extent of screening will depend on the specific equipment to be used for remediation. For purposes of this FS, it is assumed that the entire volume of soil is passed through an appropriately sized vibrating screen. Because contaminated particulates might

adhere to the surface of the rocks, they will then be washed. The washwater generated would be used to help maintain the compost moisture content, and therefore treatment of the water will not be required. The screened soil will then be placed in the mixing area.

The mixing area will consist of four open-top, steel bins. Three of these will be used to mix soil and amendment. The fourth will be used to receive and temporarily store the organic amendment that will be delivered daily.

Several amendment compositions were evaluated in a pilot test with explosives-contaminated soil conducted at another site (R.F. Weston Inc., 1992). Based on these results, composting with either horse or cow manure was found to be more effective than chicken manure. Because cow manure is readily available in the BAAP area and less expensive than horse manure, it is proposed to use the amendment composition with cow manure for this application.

The most effective soil loading volume as a percentage of total compost volume appeared to be between 10 and 25 percent (R.F. Weston Inc., 1992). Greater volume loadings significantly reduce the degradation potential of the explosives, because a high soil loading inhibits self-heating. For the development of costs and operating parameters in the FS, a soil loading of 20 percent is assumed. The soil loading has the single largest effect on the economics of the composting system. Changes in soil loading greatly influence the volume of amendment required, the size of the facility necessary to process the compost mixture, and the remediation period.

A volume of screened soil will be placed into one of the mixing bins, four volumes of amendment will be added, and the materials will be combined using a front-end loader. Multiple mixing bins will allow for a completed batch to be removed from one bin while mixing is being done in a second and screened soil is being added to a third. The mixed batches will be loaded into a dump truck and delivered to the windrow pad area. At the windrow pad area, a front-end loader will be used to form the mixture into a windrow on the pad.

For purposes of the FS, it is assumed that soil excavation and compost preparation will be performed five days per week, and that a total of 200 cubic yards of soil/amendment mix will be prepared each of those days.

Windrow Composting. The following conceptual description of windrow composting was based on the pilot test results and discussions with Roy F. Weston, Inc. The size

and operating parameters of an actual facility might be modified based on the results of a site-specific treatability study for BAAP.

The primary design parameter is the assumption that a composting period of 45 days will be required to degrade explosives to acceptable levels using windrows. A longer composting period could be required from November through March because of low ambient air temperatures.

For purposes of costing this alternative, it was assumed that four 88 by 200-foot temporary buildings would be erected on a single asphalt pad. Each building would be capable of enclosing two 150-foot-long windrows, with room available to maneuver a mechanical windrow machine. Structures, by Sprung Structures Inc., or equivalent, consisting of an external frame with plastic tensioned between the bars of the frame, would be suitable for this application. The primary benefits to covering the windrows are:

- To reduce dispersion of material due to wind erosion
- To minimize leachate by eliminating direct precipitation and storm water run-on
- To better control temperature and moisture by reducing air exchange with the external atmosphere

Each working day, until windrows are completed, a new batch of compost mixture will either be used to start a new windrow or added as a new segment to an existing windrow. The windrow machine will then pass over the new compost to fluff it, aerate it, and establish the windrow. Once established, a windrow will need to be turned periodically by the windrow turning machine. Based on the pilot test results, it is assumed that the turning will be conducted once every other day. At the third or fourth week, the volume of the windrow would be reduced by microbial activity so the windrow could be consolidated using a front-end loader. After a given windrow segment had composted for 45 days (seven weeks), it will be sampled to verify that remedial performance standards (RGs) were met. Four composite samples will be collected from each windrow for verification analysis. If so, the compost will be loaded into a dumptruck and stockpiled in the treated soil area for replacement in the pit excavation. If the RGs are not achieved, composting would be continued until the requirements are met.

Aeration for the compost matrix is provided by the windrow-turning machine, a self-propelled machine using a rotating drum with multiple short blades. As the machine moves along the windrow, the drum cuts into it, macerating and fluffing the material, which allows air to be introduced into the compost matrix.

This process increases the volume of the windrow by approximately 20 percent, admitting an excess amount of oxygen to maintain microbial activity but releasing heat and water vapor.

The loss of heat and water can adversely affect the activity of the microbial populations. Enclosing the windrows within a covered structure will help reduce heat loss by maintaining a more uniform air temperature in the immediate vicinity of the material. To combat moisture loss, water would be added to the windrows as needed.

Compost Disposition. The compost period assumed for the windrow systems was developed based on the remedial goals for the project (i.e., reducing contaminant concentrations to levels that are protective of human health and the environment). It is anticipated that a compost period of up to 45 days will be required to meet these goals. After the 45-day period, verification sampling and analysis will be conducted, and the compost will be replaced in the waste pits excavation. It is also expected that elevated nitrate concentrations will appear in the "clean" soil due to the bicrobial activity.

Many of the materials in the compost amendment, such as the manure, will be expected to decompose within the same 45-day period. However, some of the components in the amendment, particularly vegetable matter such as straw, are more difficult to decompose because of lignins and will continue to do so beyond the 45 days.

This post 45-day phase of composting is referred to as "curing," and results in the production of stabilized compost. (Stabilized compost requires no additional nutrients and has a low oxygen demand.) While curing will be enhanced by active compost management, such as will occur in the windrows, it will also proceed, but more slowly, if the compost is not actively managed and the treated soil is replaced into the ground.

Utilities. Common utilities requirements for the windrow system include:

- A continuous water supply is required to provide moisture for the compost mixture. If supplies are insufficient and facility water is not available, a water tank truck could be brought on the site. The water for the compost system is not required to be potable. Total demand for process water is estimated to be from 5 to 8 gallons per minute. In addition, sufficient water pressure must be available to support the fire protection system typically required for composting facilities.

- Electrical service of 220/440-V sufficient for a normal equipment maintenance facility is required. This should be sufficient to provide 200-ampere, 120-V, 1-phase service for the administrative and personnel spaces.

Personnel. Six operating personnel will be required for windrow composting. This will include three equipment operators to handle the windrow machine, front-end loader, and dumptruck, a maintenance supervisor, a project supervisor, and an administrative assistant/clerk. The operations schedule will typically consist of 8-hour shifts, five days per week.

Personnel exposed to contaminated soil are subjected to the Occupational Safety and Health Administration requirements for hazardous waste site operations (29 CFR 1910-120), including requirements for personal protective equipment (as dictated by the specific site conditions and contaminants), physical examinations, and hazardous waste site training.

Laboratory Analysis of Waste Feed. Laboratory analyses for the following key physical and chemical properties of the contaminated soil and the compost matrix prior to composting would be conducted:

- Density -- to determine amendment mixing ratio, compost processing time, and handling requirements.

- Moisture content -- to determine additional moisture requirements.

- DNT and other contaminant concentrations -- to determine personnel protection needs and to provide a baseline for evaluating the effectiveness of treatment.

Following composting, the compost matrix will again be analyzed for DNT and other contaminant concentrations to verify that the remediation criteria were met.

Treatability Investigations. The composting system for this site is based on the results of pilot tests conducted at a similar U.S. Army site (R.F. Weston Inc., 1992). These pilot tests were conducted with soils containing trinitrotoluene and other explosives. The explosive of concern at BAAP is 24DNT. It is anticipated that because of the similarity of the trinitrotoluene and DNT explosives, the results of the pilot tests at the other site will be generally applicable to BAAP. However, site-specific treatability investigations will be necessary to verify the feasibility of composting DNT contaminated soil at BAAP and to obtain design and process operating information.

Implementation Time. The time required to implement composting on site would include the time required for the contractor procurement process, site preparation and construction, and the composting period. For purposes of the FS, a period of two years is assumed to complete these activities.

**10.1.4.2 Cost Estimate.** For cost-estimating purposes, the following assumptions were made:

- 3 acre treatment area
- 0.25 acre parking area
- 1.75 acre stockpiles, preparation, and staging area
- one concrete decon pad
- 5,700 cubic yards of 24DNT-contaminated soil
- 30 borings (10 per burn pit)

The cost estimate for this alternative is shown in Table 10-10. Cost, material usage, and vendor information are provided in Appendices E.1, E.2, and E.3, respectively.

**10.1.5.3 Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 10-11. Full-scale treatability studies done by Roy F. Weston Inc. for the U.S. Army Corps of Engineers Research and Development group have demonstrated that the composting alternative has the potential for meeting the remedial action objective for the subsurface soils at the Deterrent Burning Ground.

### 10.1.6 Comparative Analysis of Alternatives

In this section, advantages and disadvantages of each alternative are compared for each of the evaluation criteria. A comparative summary is provided in Table 10-12.

**10.1.6.1 Overall Protection of Human Health and the Environment.** Each of the Alternatives DBG-SB1, -SB2, -SB4, -SB7, and -SB8 meet the human health-based and leaching potential response objectives. There is no unacceptable environmental risk posed by chemicals in subsurface soils.

**10.1.6.2 Compliance with ARARs.** There are no promulgated chemical-specific ARARs for the Contaminants of Concern identified in subsurface soils; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Location- and action specific ARARs identified for the selected alternative will be complied with during implementation.

**10.1.6.3 Long-Term Effectiveness and Permanence.** For Alternatives DBG-SB1 and DBG-SB2, contaminant levels are not expected to decrease significantly over time, although institutional controls should effectively limit public access and use of the site. Alternative DBG-SB2 will reduce the potential of groundwater contamination through leaching. Each of the Alternatives DBG-SB4, -SB7, and -SB8 will reduce concentrations of 24DNT to below the recommended action level. Alternatives DBG-SB4 and -SB7 use remedial technologies that may produce a secondary waste stream (i.e., filter cake and bottom/fly ash, respectively) that require additional disposal. Alternative DBG-SB8 produces a compost product that does not pose an unacceptable risk to human health and that will not require additional long-term management and controls.

**10.1.6.4 Reduction of Toxicity, Mobility, and Volume.** Alternatives DBG-SB1 and DBG-SB2 do not include provisions for reducing the toxicity, mobility, or volume of chemicals in subsurface soil. Alternative DBG-8 is the only evaluated option that will reduce the toxicity, mobility, and volume of subsurface chemicals without producing a secondary waste stream. Although Alternatives DBG-SB4 and -SB7 will reduce toxicity, mobility, and volume of chemicals at the site, ultimate contaminant toxicity and volume are not reduced but only transferred to the secondary waste disposal facility.

**10.1.6.5 Short-Term Effectiveness.** Alternatives DBG-SB1 and -SB2 will not pose significant adverse short-term impact to site workers, community, or the environment. Because of the relative remoteness of the site, nuisance factors such as noise and odor related to remedial actions performed during implementation of Alternatives DBG-SB2, -SB4, -SB7, and -SB8 will not significantly impact the adjacent community.

**10.1.6.6 Implementability.** There are no significant impediments to implementing Alternative DBG-SB1. Incineration and composting of explosives-contaminated soil (Alternatives DBG-SB7 and -SB8, respectively) have been successfully demonstrated at U.S. Army sites with similar contaminants. Capping (DBG-SB2) is a proven technology for reducing leaching potential. The technical feasibility of implementing Alternative DBG-SB8 will need to be confirmed via treatability testing. Although soil washing (DBG-SB4) has not been successfully demonstrated for explosives- or propellant-contaminated soil, it is expected that treatability studies will show this treatment to be effective.

**10.1.6.7 Cost.** Alternative DBG-SB1 has a total 30-year present worth cost of $118,000. The 30-year present worth cost of DBG-SB2 is $642,000 and of DBG-SB4 is $4,993,000. Alternative DBG-SB7 has a total 30-year present worth cost of $6,553,000 and DBG-SB8, $4,461,000.

### 10.1.7 Preferred Alternative Selection

Based on the results of the detailed analysis, the preferred alternative for subsurface soils at the Deterrent Burning Ground is DBG-SB4, Soil Washing. This alternative was selected over the others because it meets the remedial action objectives for the site, is the easiest to implement, and is the most cost efficient of the treatment alternatives. If composting of residuals is chosen, there would be no secondary wastes for disposal.

The contamination is located in the subsurface soils in the former burn pits. It is not likely that construction workers will be excavating soil in the burn pits but contaminants in the pits may be contributing to groundwater contamination beneath the site. Therefore, at this time, the burn pits would require remediation.

### 10.2 GROUNDWATER ALTERNATIVES

The following groundwater alternatives were retained after the development and initial screening in Section 4.0:

- Minimal Action (DBG-GW1)
- IRM and Carbon Adsorption (DBG-GW2)
- IRM and Air stripping/Carbon Adsorption (DBG-GW4)
- IRM and Resin Adsorption (DBG-GW5)
- IRM and UV Reduction/Carbon Adsorption (DBG-GW7)

Minimal Action was retained because it will serve as a baseline for the other groundwater alternatives. Each of the treatment technologies have been evaluated for the Propellent Burning Ground (see Section 9.0). If remedial action is chosen for groundwater at the Deterrent Burning Ground, the treatment facility at the Propellent Burning Ground will be used. This is reflected in the treatment alternatives described in this section.

#### 10.2.1 Alternative DBG-GW1: Minimal Action

This subsection describes the minimal action alternative, provides a cost estimate, and evaluates the alternative using the seven criteria.

**10.2.1.1 Description.** The Minimal Action alternative is developed to assess impacts on human health and the environment if no remedial actions are implemented. The following components comprise this alternative:

- groundwater monitoring with five-year site reviews
- institutional controls
- educational programs

Institutional Controls. Implement institutional controls in the form of deeds, zoning, or both if the site becomes inactive. The controls will restrict use of groundwater within and around the site. These controls will be drafted, implemented, and enforced in cooperation with state and local governments if the site became inactive.

Educational Programs. Conduct periodic public meetings and presentations to increase public awareness. This will help keep the public informed of the site status, including both its general condition and remaining contaminant levels. This could

be accomplished by conducting annual presentations at public hearings involving the appropriate regulatory agency. Findings from the monitoring program for the previous year could be presented and discussed at the hearing.

Groundwater Monitoring. Data collected during the groundwater monitoring program will provide information for the recommended five-year reviews. The reviews will determine whether human health and the environment are protected. If appropriate, remedial actions may be initiated. The ongoing monitoring program defined in the October 30, 1992 "Modification of Conditional Plan Approval of In-field Conditions Report" (WDNR, 1992) is attached as Appendix D.1. The purpose of this BAAP-wide sampling and analyses program is to monitor contamination migration and assess future environmental impacts. The monitoring locations, analytical parameters, and monitoring frequency pertinent to the Deterrent Burning Ground are presented in Table 10-1. One additional monitoring well, DBM-82-02, has been added to the current program.

**10.2.1.2 Cost Estimate.** The 30-year present-worth cost of this alternative is estimated at $845,000. This includes a capital cost of $10,000, no indirect costs, and a total present-worth operating cost of $835,000 (Table 10-13). Yearly costs for the ongoing groundwater monitoring program are from Olin Corporation (Olin, 1993).

Operating expenditures include installation costs for replacement of monitoring wells during year 16 of the monitoring program. A failure rate of 2 percent of wells being monitored is assumed. For costing purposes, a 30-year monitoring program is used, consistent with guidance from the USEPA (USEPA, 1988).

**10.2.1.3 Alternative Evaluation.** The assessment of this alternative against the evaluation criteria is presented in Table 10-14. This alternative would meet all but one of the remedial action objectives. The aquifer is not a water supply and by monitoring plume migration, exposure is prevented.

### 10.2.2 Alternative DBG-GW2: IRM and Carbon Adsorption

This subsection describes the alternative that uses the upgraded groundwater treatment facility for the Propellant Burning Ground groundwater plume described in Subsection 9.4.2.1. The IRM and carbon adsorption groundwater treatment facility is shown in Figure 9-18.

**10.2.2.1 Description**. The IRM and carbon adsorption alternative would consist of constructing a groundwater extraction system and transporting groundwater to the IRM and Carbon Adsorption facility at the Propellent Burning Ground. The groundwater would be treated in the IRM facility and the new carbon adsorption facility to remove or reduce contaminants (i.e., 26DNT, 112TCE, CR, HG, BE, MN, and SO4). The key components of the existing conditions alternative are:

- site preparation and mobilization
- extraction of contaminated groundwater
- transportation of groundwater to treatment facility at the Propellent Burning Ground
- IRM and Carbon Adsorption treatment (see Subsection 9.4.2.1)
- groundwater monitoring with five-year site reviews (see Subsection 10.2.1.1)

IRM and carbon adsorption treatment of groundwater is similar to that discussed in Subsection 9.4.2.1. The groundwater monitoring program would be identical to that discussed in Subsection 10.2.1.1. The other components of this alternative are discussed in the following paragraphs.

<u>Site Preparation and Mobilization</u>. A staging area for construction materials would be established in the northeast portion of the Deterrent Burning Ground (Figure 10-7). A portion of the staging area would be covered to protect equipment from inclement weather. A permanent, heated pre-engineered building would be provided to house groundwater extraction equipment and instrumentation as well as allow protection from inclement weather while filling the frac tank.

A parking area for heavy equipment and construction-support trailers would also be located in the northeast portion of the Deterrent Burning Ground. The staging, parking, and building areas would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot.

A concrete decontamination pad would be constructed near the construction-support trailers. The pad would be used to decontaminate equipment used to drill the extraction wells before the equipment can leave the exclusion zone. The pad would be designed to collect contaminated water in a sump and pump it into a collection/ storage tank for disposal.

Equipment mobilized to the site includes earth-moving equipment (e.g., backhoes, front-end loaders, and bulldozers), drill rig(s), dumptrucks, and construction-support trailers.

Groundwater Extraction Wells. The thin nature and relatively slow groundwater velocity in the elevated aquifer inhibits contaminant migration and also makes efficient removal of contaminated groundwater difficult. The combination of the thin aquifer and the relatively low hydraulic conductivity may limit the supportable pumping capacity of a well or system of extraction wells. During well purging, pumping rates on the order of 2 gallons per minute have been maintained in monitoring wells in this area. However, this rate may not be sustainable if excessive drawdowns occur. Under these conditions, a pulsed pumping technique may be needed.

Groundwater Extraction System. The groundwater extraction system shown in Figure 9-6 was designed to intercept and capture the contaminant plume as it is currently defined. A total of six extraction wells will be installed; four wells will be spaced equidistant from each other and two monitoring wells (ELM-89-01 and ELM-89-09); the other two extraction wells will be installed on either side of the two monitoring wells. Information obtained from the pumping test performed by ABB-ES at the site indicates that the maximum total flow expected from these six wells is two gallons per minute.

The elevated aquifer is relatively thin below the site and in the area of the proposed extraction wells is estimated to be approximately three feet thick; this aquifer depth is not likely to provide the cone of influence needed to draw the contaminants to the extraction well. The clay layer between the elevated aquifer and the regional aquifer is very thin and great care must be taken when constructing the wells to avoid transferring contaminants from the elevated aquifer to the regional aquifer. Water in the well must be deep enough to support pumping; therefore, the clay layer must be penetrated by the well and subsequently sealed with an impermeable material to assure no flow between the two aquifers.

Each extraction well will be 10 inches in diameter and constructed of stainless steel. Grain size of the sandpack material in the annular space around the screen will be compatible with the slot size of the screen. The remaining annular space will be backfilled and sealed with bentonite. Protective casings will be installed and cemented in place. The wells will each be approximately 150 feet deep. Each well will contain a submersible pump with sufficient capacity to extract groundwater at the

rate of 0.5 gpm plus additional pumping capacity that could be utilized in the event the neighboring well or well pump was to fail.

The groundwater extracted from each well will be pumped to a 25,000-gallon frac tank stored inside the heated, 50-foot by 100-foot building at the staging area. The frac tank will be equipped with level control switches that will signal an alarm system at high level, and shut down the extraction pumps at high, high level. Once the tank is full, it can be transported by truck to the facility at the Propellant Burning Ground. A maximum production of 25,000 gallons per week is expected from the groundwater extraction system.

Transportation of Groundwater. The volume of groundwater to be transported is estimated to be relatively low (up to 25,000 gallons per week). Therefore, this alternative would utilize 25,000-gallon frac tanks for storage and transported by 6,000 gallon tanker trucks as opposed to installing a buried force main that would be over three miles long.

**10.2.2.2 Cost Estimate**. For cost-estimating purposes, the following assumptions were made:

- 0.75-acre staging area
- 0.25-acre parking area
- pre-engineered building (50 feet x 100 feet)
- three phase power not available
- six extraction wells
- 25,000 gallons of groundwater to be treated weekly
- concrete decon pad
- transportation to treatment facility via 25,000-gallon frac tank

The cost estimate for this alternative is shown in Table 10-15. Cost information is provided in Appendix E.1.

**10.2.2.3 Alternative Evaluation**. The assessment of this alternative against the evaluation criteria is presented in Table 10-16. The IRM and carbon adsorption alternative would be designed to meet all but one of the remedial action objectives for groundwater at the Deterrent Burning Ground because the source of contamination has not been identified.

### 10.2.3 Alternative DBG-GW4: IRM and Air Stripping-Carbon Adsorption

This subsection describes the alternative that uses the upgraded groundwater treatment facility for the Propellant Burning Ground groundwater plume described in Subsection 9.4.3.1 (see Figure 9-19).

**10.2.3.1 Description.** The IRM and Air Stripping-Carbon Adsorption alternative would consist of constructing a groundwater extraction system and transporting groundwater to the IRM and Air Stripping Carbon Adsorption facility at the Propellent Burning Ground. The groundwater would be treated in the modified IRM facility and the new air stripping - carbon adsorption facility to remove or reduce contaminants (i.e., 26DNT, 112TCE, CR, HG, BE, MN, and SO4). The key components of the air stripping-carbon adsorption alternative are:

- site preparation and mobilization (see Subsection 10.2.2.1)
- extraction of contaminated groundwater (see Subsection 10.2.2.1)
- transportation of groundwater to treatment facility at the Propellent Burning Ground (see Subsection 10.2.2.1)
- IRM and Air Stripping-Carbon Adsorption treatment (see Subsection 9.4.3.1)
- groundwater monitoring with five-year site reviews (see Subsection 10.2.1.1)

IRM and air stripping-carbon adsorption treatment of groundwater is similar to that discussed in Subsection 9.4.3.1. Site preparation and mobilization, extraction of contaminated groundwater, and transportation of contaminated groundwater are identical to those discussed in Subsection 10.2.2.1. The groundwater monitoring program would be identical to that discussed in Subsection 10.2.1.1.

Components of this alternative are identical to those discussed in the previous alternative and are therefore not discussed here. Only the method of groundwater treatment differs between alternatives and this is discussed in the groundwater treatment alternatives section for the Propellent Burning Ground.

**10.2.3.2 Cost Estimate.** For cost-estimating purposes, the following assumptions were made:

- 0.75-acre staging area
- 0.25-acre parking area

- pre-engineered building (50 feet x 100 feet)
- three-phase power not available
- six extraction wells
- 25,000 gallons of groundwater to be treated weekly
- concrete decon pad
- transportation to treatment facility via 25,000 gallon frac tank

The cost estimate for this alternative is shown in Table 10-17. Cost information is provided in Appendix E.1.

**10.2.3.3 Alternative Evaluation.** The assessment of this alternative against the evaluation criteria is presented in Table 10-18. The air stripping-carbon adsorption alternative would be designed to meet some remedial action objectives for groundwater at the Deterrent Burning Ground. Until the source of contamination is identified and remediated, impacts to groundwater would be likely to continue.

### 10.2.4 Alternative DBG-GW5: IRM and Resin Adsorption

This subsection describes the alternative that uses the upgraded groundwater treatment facility for the Propellant Burning Ground groundwater plume described in Subsection 9.4.4.1 (see Figure 9-20).

**10.2.4.1 Description.** The IRM and Resin Adsorption alternative consists of constructing a groundwater extraction system and transporting groundwater to the IRM and Resin Adsorption facility at the Propellent Burning Ground. The groundwater would be treated in the modified IRM facility and new resin adsorption facility to remove or reduce contaminants (i.e., 26DNT, 112TCE, CR, HG, BE, MN, and SO4). The key components of the resin adsorption alternative are:

- site preparation and mobilization (see Subsection 10.2.2.1)
- extraction of contaminated groundwater (see Subsection 10.2.2.1)
- transportation of groundwater to treatment facility at the Propellent Burning Ground (see Subsection 10.2.2.1)
- IRM and Resin Adsorption treatment (see Subsection 9.4.3.1)
- groundwater monitoring with five-year site reviews (see Subsection 10.2.1.1)

IRM and resin adsorption treatment of groundwater is similar to that discussed in Subsection 9.4.4.1. Site preparation and mobilization, extraction of contaminated

groundwater, and transportation of contaminated groundwater are identical to those discussed in Subsection 10.2.2.1. The groundwater monitoring program would be identical to that discussed in Subsection 10.2.1.1.

Components of this alternative are identical to those discussed in the IRM and carbon adsorption alternative and are, therefore, not discussed here. Only the method of groundwater treatment differs between alternatives and this is discussed in the groundwater treatment alternatives section for the Propellent Burning Ground.

**10.2.4.2 Cost Estimate.** For cost-estimating purposes, the following assumptions were made:

- 0.75-acre staging area
- 0.25-acre parking area
- pre-engineered building (50 feet x 100 feet)
- three phase power not available
- six extraction wells
- 25,000 gallons of groundwater to be treated per week
- concrete decon pad
- transportation to treatment facility via 25,000-gallon frac tank

The cost estimate for this alternative is shown in Table 10-19. Cost information is provided in Appendix E.1.

**10.2.4.3 Alternative Evaluation.** The assessment of this alternative against the evaluation criteria is presented in Table 10-20. The IRM and Resin Adsorption alternative would be designed to meet some of the remedial action objectives for groundwater at the Deterrent Burning Ground. Until the source of contamination can be identified and remediated, impacts to groundwater would be likely to continue.

### 10.2.5 Alternative DBG-GW6: UV/Reduction-Carbon Adsorption

This subsection describes the alternative that uses the upgraded groundwater treatment facility for the Propellant Burning Ground groundwater plume described in Subsection 9.4.5.1 (see Figure 9-21).

**10.2.5.1 Description.** The IRM and UV/Reduction-Carbon Adsorption alternative would consist of constructing a groundwater extraction system and transporting

groundwater to the IRM and UV/Reduction-Carbon Adsorption facility at the Propellent Burning Ground. The groundwater will be treated in the modified IRM facility and new UV/Reduction-Carbon Adsorption facility to remove or reduce contaminants (i.e., 26DNT, 112TCE, CR, HG, BE, MN, and SO4). The key components of the UV/reduction-carbon adsorption alternative are:

- site preparation and mobilization (see Subsection 10.2.2.1)
- extraction of contaminated groundwater (see Subsection 10.2.2.1)
- transportation of groundwater to treatment facility at the Propellent Burning Ground (see Subsection 10.2.2.1)
- IRM and Resin Adsorption treatment (see Subsection 9.4.3.1)
- groundwater monitoring program with five-year site reviews (see Subsection 10.2.1.1)

IRM and UV/Reduction-Carbon Adsorption treatment of groundwater is similar to that discussed in Subsection 9.4.5.1. Site preparation and mobilization, extraction of contaminated groundwater, and transportation of contaminated groundwater are identical to those discussed in Subsection 10.2.2.1. The groundwater monitoring program would be identical to that discussed in Subsection 10.2.1.1.

Components of this alternative are identical to those discussed in the IRM and carbon adsorption alternative and are, therefore, not discussed here. Only the method of groundwater treatment differs between alternatives and this is discussed in the groundwater treatment alternatives section for the Propellent Burning Ground.

**10.2.5.2 Cost Estimate.** For cost-estimating purposes, the following assumptions were made:

- 0.75-acre staging area
- 0.25-acre parking area
- pre-engineered building (50 feet x 100 feet)
- three-phase power not available
- six extraction wells
- 25,000 gallons of groundwater to be treated per week
- concrete decon pad
- transportation to treatment facility via 25,000-gallon frac tank

The cost estimate for this alternative is shown in Table 10-21. Cost information is provided in Appendix E.1.

**10.2.5.3 Alternative Evaluation.** The assessment of this alternative against the evaluation criteria is presented in Table 10-22. The IRM and UV/Reduction-Carbon Adsorption alternative will meet some remedial action objectives for groundwater at the Deterrent Burning Ground. Until the source of contamination can be identified and remediated, impacts to groundwater would be likely to continue.

### 10.2.6 Comparative Analysis of Groundwater Alternatives

In this section, the advantages and disadvantages of each alternative are compared using the evaluation criteria. A comparative summary is provided in Table 10-23.

**10.2.6.1 Overall Protection of Human Health and the Environment.** Under existing conditions, there is limited potential for public exposure to contaminated groundwater. Alternative DBG-GW1 eliminates potential risk posed by the groundwater at the Deterrent Burning Ground through institutional controls. Alternatives DBG-GW2, 4, 5, and 6 include extraction, if implementable, of contaminated groundwater and therefore may result in eliminating potential exposure to some contaminants in the groundwater. Significant technical difficulties associated with the extraction of groundwater from the elevated Deterrent Burning Ground flow system are described elsewhere in this subsection.

**10.2.6.2 Compliance with ARARs.** Although chemical-specific ARARs will not be met by DBG-GW1, this alternative will meet the response objective identified at the outset of this FS Report by preventing exposure to groundwater containing chemical concentrations exceeding RGs. The other alternatives, which involve treatment, will likely provide compliance with chemical-specific ARARs for the treated groundwater, however, the potential for effective extraction of groundwater from the elevated flow system is extremely low. Groundwater beneath the site will not meet chemical-specific ARARs until the source area is identified and remediated. Alternatives involving remedial action could be designed and constructed to comply with location-and action-specific ARARs.

**10.2.6.3 Long-term Effectiveness and Permanence.** Under DBG-GW1, the minimal action alternative, some contaminants are expected to remain at concentrations at or above groundwater protection standards during the proposed 30-year monitoring period, although removal of source wastes (if found) may decrease chemical concentrations in groundwater. Under the treatment alternatives, contaminants are also expected to remain at concentrations at or above groundwater protection until the source area can be identified and remediated.

**10.2.6.4 Reduction in Toxicity, Mobility, and Volume through Treatment.** Alternative DBG-GW1 will not result in reduction of toxicity, mobility, or volume of contaminants in the groundwater. The proposed extraction system in each of the treatment alternatives, if effective, may reduce the mobility of the contaminants in the groundwater, but until the source area is remediated the volume of contaminants will not be reduced. The toxicity of the groundwater is reduced in each of the treatment alternatives by transferring contaminants to carbon and destroying them with carbon reactivation in Alternatives DBG-GW2, and 4; by transferring them to resin and destroying them through reactivation in Alternative DBG-GW5; and by destroying them with UV light in Alternative DBG-GW6.

**10.2.6.5 Short-term Effectiveness.** Alternative DBG-GW1 includes no response action, thus human health and the environment will not be adversely affected by its implementation. Each of the treatment alternatives require only minimal response action including installation of extraction wells and associated piping. With proper precautions, human health and the environment will not be adversely affected during installation of the extraction system. Low-level threats to community and environment may exist in the transportation of untreated groundwater to the Propellant Burning Ground, but if safe working practices are followed those threats are minimized.

**10.2.6.6 Implementability.** Alternative DBG-GW1 involves the establishment of a groundwater monitoring program and, if necessary, institutional controls. These tasks are easily implemented. The installation of extraction wells under each of the treatment alternatives is a somewhat complicated task. The difference in elevation between the water level of the elevated aquifer and the underlying clay layer is not thick enough to support pumping. Care must be taken when penetrating the clay layer to seal off the flow from the elevated aquifer to the regional aquifer, and vice versa. Improper construction of the wells could alter existing contaminant migration pathways from the elevated aquifer to the regional aquifer. Contractors who will guarantee construction of these wells are not abundant. There are contractors available, however, to transport groundwater from the Deterrent Burning Ground to the treatment facility at the Propellant Burning Ground.

**10.2.6.7 Cost.** Alternative DBG-GW1 has a 30-year present worth of $845,000. The 30-year present worth of Alternative DBG-GW2 is $2,008,000 and of Alternative DBG-GW4 is $2,008,000. Alternative DBG-GW5 has a 30-year present worth of $2,008,000 and Alternative DBG-GW6 has a 30-year present worth of $2,008,000.

### 10.2.7 Preferred Alternative Selection

Based on the results of the detailed analysis, the preferred alternative for groundwater at the Deterrent Burning Ground is DBG-GW1, Minimal Action with the recommendation that further subsurface investigation be done to locate the source(s) of 112TCE. DBG-GW1 will comply with all the remedial action objectives except to prevent further contamination of the elevated groundwater system. Minimal action and further investigation are recommended rather than groundwater extraction and treatment because the thinness of the elevated aquifer will not likely support effective groundwater extraction. At present the elevated system shows no signs of contaminating the regional aquifer. The recommended alternative introduces no secondary wastes, is the easiest to implement, and is the most cost efficient of the evaluated alternatives.

## 11.0 DETAILED ANALYSIS OF NITROGLYCERINE POND/ROCKET PASTE AREA ALTERNATIVES

Remedial alternatives for surface soil/sediment, and surface water remediation at the NG/RPA are evaluated in this section using seven evaluation criteria recommended in USEPA's RI/FS guidance (USEPA, 1988). These criteria, described in Subsection 1.5, serve as the basis for the detailed analysis. The alternatives evaluated in this section were retained for detailed evaluation after initial screening of alternatives in Section 5.0.

The conceptual design discussed in each section is preliminary and has been developed for evaluation and cost-estimating purposes. The relative advantages and disadvantages of each alternative are compared using the evaluation criteria. The recommended remedial alternatives for surface soil/sediment and surface water remediation at the NG/RPA are then selected based on the alternative comparison. The recommended remedial alternatives are presented at the conclusion of each media-specific subsection.

Appendix F.1 contains cost backup information, Appendix F.2 contains vendor information, and Appendix F.3 contains quantity and material usage calculations.

### 11.1 SURFACE SOIL/SEDIMENT ALTERNATIVES

The following five surface soil/sediment remedial alternatives were retained for detailed analysis:

- Minimal Action (NG/RPA-SS1)
- Soil Cover (NG/RPA-SS2)
- Excavation/Solidification/On-site Disposal (NG/RPA-SS3)
- Excavation/Off-site Disposal (NG/RPA-SS4)
- In-situ Solidification/Stabilization (NG/RPA-SS5)

Minimal Action serves as a baseline for the other surface soil alternatives. Soil Cover is designed to reduce human health and ecological risks by covering the contaminated surface soil/sediment. Excavation/Solidification/On-site Disposal is designed to reduce human health, ecological, and groundwater risks at the NG/RPA

by removal and treatment of contaminated surface soil/sediment followed by disposal at the Propellant Burning Ground. Excavation/Off-site disposal is designed to reduce human health, ecological, and groundwater risks at BAAP by removal of the contaminated surface soil/sediment from the BAAP site. In-situ solidification/ stabilization is designed to reduce human health, ecological, and groundwater risks at BAAP by treatment of contaminated surface soil/sediment to eliminate the contaminants mobility.

### 11.1.1 Alternative NG/RPA-SS1: Minimal Action

This subsection describes the minimal action alternative, provides a cost estimate, and evaluates the alternative using the seven evaluation criteria.

**11.1.1.1 Description.** The minimal action alternative is developed to assess impacts on human health, the environment, and groundwater if no remedial technologies were implemented. This alternative would take approximately four months to implement. Beneficial results would be seen immediately. The key components of the alternative are:

- Fencing and warning signs
- Institutional controls
- Education programs
- Annual site inspection
- Groundwater monitoring program
- Five-year site review

The key components are described in the following paragraphs.

Fencing and Warning Signs. A 6-foot-high, chain-link fence with three-strand barbed wire would be installed to discourage entry to the NG/RPA. The fence would be installed along the perimeter of the NG/RPA as shown in Figure 11-1. The proposed fence would be approximately 33,000 linear feet, including swing gates across the entrances and would enclose an area of approximately 760 acres. Warning signs would be posted along the fence at 50-foot intervals and on entrance gates.

Institutional Controls. At present, the Army has no plans to designate the area within BAAP for residential or public use. This component of the minimal action alternative would be implemented if BAAP were to be decommissioned.

Institutional controls in the form of deed and/or zoning restrictions would be needed to prohibit future land use. These controls would be drafted, implemented, and enforced in cooperation with state and local governments.

Educational Programs. This component involves conducting public meetings and presentations to keep the public informed of the site status. Site status refers to both the general condition of the site and remaining contaminant levels. In addition, informational mailings would be sent to community citizens who may utilize BAAP property for hunting or farming.

Annual Site Inspection. An annual site inspection would be conducted to check fence and sign integrity. Repairs would be made as needed.

Groundwater Monitoring Program. The monitoring program would be implemented to evaluate potential migration of contaminants from the NG/RPA to groundwater.

The groundwater monitoring program to be implemented would be a continuation of the ongoing monitoring program defined in the October 30, 1992 "Modification of Conditional Plan Approval of In-field Conditions Report" (WDNR, 1992) attached in Appendix D.1. The purpose of this BAAP-wide sampling and analyses program is to monitor contamination migration and assess future environmental impacts. The monitoring locations, analytical parameters, and monitoring frequency pertinent to the NG/RPA are presented in Table 11-1.

Five-Year Site Review. The five-year site review is applicable to this alternative.

**11.1.1.2 Cost Estimate.** The cost estimate for this alternative is shown in Table 11-2. The total cost for NG/RPA-SS1 is estimated to be $2,425,000.

**11.1.1.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 11-3.

### 11.1.2 Alternative NG/RPA-SS2: Soil Cover

This subsection describes the soil cover alternative, provides a cost estimate for the alternative, and evaluates the alternative using the seven evaluation criteria.

**11.1.2.1 Description.** The soil cover alternative consists of placing a soil cover over the Rocket Paste Area ditches, the Main Ditch, and sediment in the Nitroglycerine, Overflow, and Rocket Paste ponds. A soil cover (2-foot minimum) would be placed over the rocket paste ditches and the Overflow and Rocket Paste Pond sediment. A 2-foot soil cover would be placed over the Nitroglycerine Pond sediment; water would be treated and discharged downstream (see Subsection 11.2). Figure 11-2 shows the site layout for soil/sediment remediation.

This alternative would take approximately three months to implement. Beneficial results would be seen immediately. The key components of this alternative are:

- Site preparation and mobilization
- Contaminated soil delineation
- Soil cover construction
- Post-closure maintenance
- Groundwater monitoring program (see Subsection 11.1.1.1)
- Five-year site reviews (see Subsection 11.1.1.1)

The groundwater monitoring and five-year site reviews components of this alternative would be similar to Subsection 11.1.1.1. Other key components are described in the following paragraphs.

Site Preparation and Mobilization. A stockpile area for cover soils (common borrow and vegetative soil) would be established (see Figure 11-2). The area would be large enough to provide sufficient volume for several days of filling and grading operations in the event delivery is interrupted. A parking area for construction-support trailers and heavy equipment would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot.

The surface water from the ponds must be removed prior to the start of the soil cover activities at the three pond areas. Surface water controls and remediation are addressed in Subsection 11.2.

Equipment mobilized to the site would include earth-moving equipment (i.e., backhoes, front-end loaders, and bulldozers), dump trucks, and construction-support trailers.

Contaminated Soil Delineation. It is estimated the entire area shown in Figure 11-2 will be covered, but samples should be taken during the design phase to confirm contamination extent. PB is the primary surface soil contaminant at the nitroglycerine pond and the rocket paste area. The other surface soil contaminants (i.e., 24DNT, 26DNT, CPAH, NNDPA, CR, HG, and NG) are co-located with PB. Consequently, the areas requiring remediation would be delineated using the Remediation Goal for PB (i.e., 30 mg/kg for soil and 201 mg/kg for sediments). Eight additional surface soil samples will be taken from the main ditch to confirm the extent of surface contamination. At eighty-six locations (seventy-eight existing and the eight new surface sample locations) soil borings will be taken to determine the vertical extent of the contamination. At each location a sample will be taken at two and four feet below ground surface. At twenty-two locations (about 25 percent) a sample from six feet bgs will be taken. This is a total of one hundred ninety four additional samples.

Soil Cover Construction. The ditches vary in width and depth across the Rocket Paste Area. In general, the ditches in the West and East Rocket Paste Area are smaller than the Main Ditch. Figure 11-3 shows a typical cross-section for the existing East and West Rocket Paste Area ditches and one for the Main Ditch. The existing cross-sectional representations of the Nitroglycerine, Overflow, and Rocket Paste Ponds are shown in Figure 11-4. The cross-sectional representations of the ponds presented in this section are intended for illustration as the exact dimensions of the ponds have not yet been characterized. These typical cross-sections are used to formulate quantities and costs for remedial alternatives.

The soil cover system would consist of a compacted common borrow soil layer (2-foot minimum) under a 3-inch layer of vegetative soil. Materials for the soil cover would be transported to the contaminated areas directly from the source or from the on-site stockpile. The cover would be spread and graded using conventional construction equipment (e.g., tracked bulldozer). Typical soil cover cross-sections for the Rocket Paste Area ditches and Main Ditch are shown in Figure 11-5. After construction of the soil cover, the Rocket Paste Area ditches would be full and could no longer accept waste water from the production facilities. The Army has indicated plans are under consideration for the future construction of a sewer system at the Rocket Paste Area. WDNR's air management program would be contacted during the design phase to discuss appropriate measures for fugitive dust control.

The Rocket Paste Area ditches would be hydroseeded, fertilized, and mulched to provide vegetation that will protect against erosion. The Main Ditch would maintain the ability to transport runoff during storm events. A layer of erosion control fabric would be installed in the Main Ditch followed by hydroseeding. The erosion control fabric typically is constructed of knitted synthetic netting interwoven with biodegradable paper strips (e.g., Supergrow(R) by Philips Fibers Corporation). This would allow a hearty growth of vegetation and allow the Main Ditch to carry water without erosion. If required, silt fence and/or haybale check dams would be included to further control erosion.

Figure 11-6 shows a typical cross-section for soil cover construction at the ponds. Compacted common borrow (2-foot minimum) would be used as fill material covered with approximately 3 inches of vegetative soil. Due to their shallow depths the overflow and rocket paste ponds would be completely filled. A drainage channel would be installed from North to South across the Rocket Paste Pond to connect the main ditches formerly leading into and out of the Rocket Paste Pond. The Nitroglycerine Pond would retain its ability to collect water but with a reduced volume.

Post-Closure Maintenance. Post-closure maintenance would include annual visual inspections, mowing, and if necessary, cover repairs. Repairs would be required if the covers were damaged by burrowing animals, vehicular traffic, erosion, or loss of vegetation. The Main Ditch would be inspected after large storm events to ensure the protective vegetative layer remained intact.

**11.1.2.2 Cost Estimate**. The cost estimate for this alternative is shown in Table 11-4. The total cost for NG/RPA-SS2 is estimated to be $2,995,000.

**11.1.2.3 Remedial Alternative Evaluation**. The assessment of this alternative using the evaluation criteria is presented in Table 11-5.

### 11.1.3 Alternative NG/RPA-SS3: Excavation/Solidification/On-site Disposal

This subsection describes the excavation/solidification/on-site disposal alternative, provides a cost estimate for the alternative, and evaluates the alternative using the seven evaluation criteria.

**11.1.3.1 Description.** This alternative consists of excavating contaminated surface soil from the Rocket Paste Area ditches and sediment from the Nitroglycerine, Overflow, and Rocket Paste ponds, treating the excavated soil/sediment on site using stabilization/solidification technology, and disposing of the treated soil/sediment at the Propellant Burning Ground. Excavations would be backfilled with common borrow and compacted. A 3-inch layer of vegetative soil would then be placed and followed by hydroseeding, fertilizing, and mulching.

The alternative is designed to meet all of the remedial action objectives for surface soil, sediment, and groundwater. The key components of the alternative are:

- Treatability testing
- Site preparation and mobilization
- Contaminated soil delineation (see Subsection 11.1.2.1)
- Soil/sediment excavation
- Stabilization/solidification
- Confirmatory sampling
- Disposal of treated soil/sediment at the Propellant Burning Ground
- Backfill excavations

Because all contaminated soil/sediment would be removed from the NG/RPA site no post-closure maintenance, groundwater monitoring, or five-year site reviews would be required. This alternative would take approximately four months to implement. Beneficial results would be seen immediately. The key components specific to this alternative are described in the following paragraphs.

Treatability Testing. A bench-scale treatability test would be required to determine the most effective additives and setting agents for treating NG/RPA soils and sediments. The bench test would also determine the proper ratio of additives/setting agents to contaminated soil. Analyses of test samples before and after treatment would include TCLP, permeability, and tests to determine uniformity of the treated product and its long-term leaching potential.

A pilot-scale treatability test would be required to determine the most cost-effective method for mixing the additives and setting agents into the soil. A small plot would be prepared at the NG/RPA for conducting the pilot test. Selected types of equipment would be tested for their potential to produce homogenous mixing at high throughput rates. Additionally, pilot tests would determine whether dry (i.e., powder)

or wet (i.e., slurry) application of the additives/setting agents is appropriate. Analyses during pilot tests would be similar to those conducted during the bench tests.

Site Preparation and Mobilization. A stockpile area for cover soils (common borrow and vegetative soil), would be established (see Figure 11-2). Dewatering and stabilization/solidification treatment areas would also be established. The stockpile areas would be large enough to provide sufficient volume for several days of activities. A parking area for construction-support trailers and heavy equipment would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot.

Concrete decontamination pads would be constructed. The pads would be used to decontaminate trucks loaded with contaminated soil as they leave the sites and would also be used to decontaminate heavy equipment used during excavation.

The surface water from the ponds must be removed prior to the start of excavation at the pond areas. Surface water remediation is addressed in Subsection 11.2.

Equipment mobilized to the site would include earth-moving equipment (i.e., backhoes, front-end loaders, and bulldozers), dump trucks, and construction-support trailers. Stabilization/solidification equipment would also be mobilized.

Most of the ditches in the East and West Rocket Paste Areas, the Main Ditch, and the ponds require remediation based on at least one clean up criteria. Therefore, all ditches and ponds will be included in this alternative. Figure 11-2 shows the area targeted for remediation.

Soil/Sediment Excavation. Surface soil in all the Rocket Paste Area ditches and the Main Ditch would be excavated to a depth of 2 feet as shown in Figure 11-7. Excavated soil would be transported to the staging area. Prior to sediment excavation, the surface water in the ponds must be removed. Sediment in the Nitroglycerine, Overflow, and Rocket Paste Ponds would be excavated to a depth of 2 feet (Figure 11-8) and dewatered at the staging area. WDNR's air management program would be contacted during the design phase to discuss appropriate measures for fugitive dust control.

Stabilization/Solidification. Contaminated surface soil and sediment would then be treated by mixing with the stabilization/solidification powder or slurry as determined during treatability tests. The treated surface soil/sediment would be in a pelletized or granular form. It is also possible for other stabilization/solidification processes to produce other forms such as large blocks or monolithic slabs.

Confirmatory Sampling. The on-site mobile laboratory would run tests on the treatment product to ensure that pre-determined QA/QC criteria are being achieved. A sampling frequency (i.e., one sample for a given volume) would be specified for S/S performed at the Propellant Burning Ground. QA/QC criteria could include TCLP limits, degree of mixing, or permeability and unconfined compressive strength (if the treatment product is a solidified mass), and freeze/thaw testing.

On-site Disposal of Treated Soil/Sediment. The treated soil/sediment would be disposed of at the Propellant Burning Ground on the racetrack area. An additional 7 acres of disposal area is required at the PBG for NG/RPA-SS3 soils. The cost of the 7 acres of additional cover materials is included in this estimate. See PBG-SS6 Paragraph 9.1.3.1 for a description of the cover.

Backfill Excavations. Excavations would be backfilled with 2 ft of common borrow and compacted. A 3-inch vegetative soil layer would be placed over this. Rocket Paste Area ditches and the Main Ditch would be backfilled as shown in Figure 11-9. The Nitroglycerine, Rocket Paste, and Overflow Pond excavations would be backfilled as shown in Figure 11-10. A drainage channel would be installed from north to south across the Rocket Paste Pond to connect the main ditches formerly leading into and out of the Rocket Paste Pond.

The Rocket Paste Area ditches would be hydroseeded, fertilized, and mulched to provide vegetation to protect against erosion. The Main Ditch would maintain the ability to transport runoff during storm events. A layer of erosion control fabric would be installed in the Main Ditch followed by hydroseeding. The erosion control fabric typically is constructed of knitted synthetic netting interwoven with biodegradable paper strips (e.g., Supergrow® by Philips Fibers Corporation). This would allow a hearty growth of vegetation and allow the Main Ditch to carry water without erosion.

**11.1.3.2 Cost Estimate Analysis**. The cost estimate for this alternative is shown in Table 11-6. The total cost for NG/RPA-SS3 is estimated to be $12,910,000.

**11.1.3.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 11-7.

### 11.1.4 Alternative NG/RPA-SS4: Excavation/Off-site Disposal

This subsection describes the excavation/off-site disposal alternative, provides a cost estimate for the alternative, and evaluates the alternative using the seven evaluation criteria.

**11.1.4.1 Description.** This alternative consists of excavation of contaminated surface soil from the Rocket Paste Area ditches and Main Ditch and sediment from the Nitroglycerine, Overflow, and Rocket Paste ponds. Excavated surface soil/sediment would be transported to a permitted off-site disposal facility. Excavations would be backfilled with common borrow, and compacted. A 3-inch layer of vegetative soil is then placed and followed by hydroseeding, fertilizing, and mulching.

The alternative is designed to meet all of the remedial action objectives for surface soil, sediment, and groundwater. This alternative would take approximately eight months to implement. Beneficial results would be seen immediately. The key components of the alternative are:

- Site preparation and mobilization (see Subsection 11.1.3.1)
- Contaminated soil delineation (see Subsection 11.1.2.1)
- Surface soil/sediment excavation (see Subsection 11.1.3.1)
- Off-site disposal of soil/sediment
- Backfill excavations (see Subsection 11.1.3.1)

This alternative would be very similar to that for the excavation/ solidification/ on-site disposal alternative NG/RPA-SS3 (Subsection 11.1.3.1) except off-site disposal would be utilized instead of stabilization/solidification and on-site disposal. Site preparation and mobilization would not involve stabilization/solidification equipment. However, a sediment dewatering/stabilizing pad would be added for sediment treatment prior to transportation to the off-site disposal facility. The off-site disposal key components specific to this alternative are described below.

Off-site Disposal of Soil/Sediment. Excavated surface soil and dewatered sediment would be loaded into trucks for transportation to the off-site disposal facility. Where feasible, soil would be loaded directly into the trucks from the excavations. Liners

would be used in the trucks. The trucks would be decontaminated prior to proceeding to the selected permitted off-site landfill facility. Characterization of the excavated surface soil/sediment would be performed at the landfill to determine whether it would be disposed of as hazardous or nonhazardous. Because only two of the 78 soil/sediment samples analyzed using TCLP failed (both failed for PB), it is expected that most of the excavated soil would be considered nonhazardous. There were no TCLP failures for any other metals. There were no TCLP tests performed for 24DNT. However, based on the relatively low (0.81 mg/kg) maximum 24DNT concentration in soil, it is likely that site soils would not fail TCLP.

WDNR's Air Management Program would be contacted during the design phase to discuss appropriate measures for fugitive dust control.

**11.1.4.2 Cost Estimate**. The cost estimate for this alternative is shown in Table 11-8. The total cost for NG/RPA-SS4 is estimated to be $34,743,000.

**11.1.4.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 11-9.

### 11.1.5 Alternative NG/RPA-SS5: In Situ Stabilization/Solidification and Soil Cover

This subsection describes the in situ S/S and soil cover alternative, provides a cost estimate for the alternative, and evaluates the alternative using the seven evaluation criteria.

**11.1.5.1 Description**. This alternative consists of treating surface soil/sediments by chemically and/or physically binding surface soil/sediments contaminants (i.e., 24DNT, 26DNT, CPAH, NNDPA, PB, CR, HG, and NG), and covering the treated material with a 2.5-foot soil cover. The 2.5-foot cover is necessary to bury the treated material below the 30-inch bgs frost line (ABB-ES, 1993a). Figure 11-2 shows the estimated area targeted for remediation. The alternative would be designed to meet all of the remedial action objectives for surface soil. This alternative would take approximately six months to implement. Beneficial results would be seen immediately. The key components of the alternative are:

- treatability testing
- site preparation and mobilization
- contaminated soil delineation (see Subsection 11.1.2.1)

- in situ S/S
- confirmatory sampling (see Subsection 11.1.3.1)
- soil cover construction (see Subsection 11.1.2.1)
- post-closure maintenance (see Subsection 11.1.2.1)
- monitoring with five-year site reviews (see Subsection 11.1.1.1)

Contaminated soil delineation and post-closure maintenance for this alternative would be similar to those discussed in Subsection 11.1.2.1. Soil cover construction for this alternative would be similar to that discussed in Subsection 11.1.2.1, except that a 2.5-foot soil cover is required versus a 2.0-foot soil cover for Alternative NG/RPA-SS2. The monitoring program for this alternative is identical to that discussed in Subsection 11.1.1.1. Other key components are discussed in the following paragraphs.

Treatability Testing. A bench-scale treatability test would be required to determine the most effective additives and setting agents for treating Nitroglycerine Pond and Rocket Paste Area soils and sediments. The bench test would also determine the proper ratio of additives/setting agents to contaminated soil. Analyses of test samples before and after treatment would include TCLP, permeability, and tests to determine uniformity of the treated product and its long-term leaching potential.

A pilot-scale treatability test would be required to determine the most cost-effective method for mixing the additives and setting agents into the soil. A small plot would be prepared at the Nitroglycerine Pond/Rocket Paste Area for conducting the pilot test. Selected types of equipment would be tested for their potential to produce homogenous mixing at high throughput rates. Additionally, pilot tests would determine whether dry (i.e., powder) or wet (i.e., slurry) application of the additives/setting agents is appropriate for the equipment used during in situ S/S. Analyses during pilot tests would be similar to those conducted during the bench tests.

Site Preparation and Mobilization. A stockpile area for storing cover soil (i.e., common borrow and vegetative soil) would be established west of the Rocket Paste Pond (Figure 11-2). A parking area for a mobile laboratory, construction-support trailers, and heavy equipment would be prepared west of the Rocket Paste Pond by grubbing, grading, and placing gravel to minimum depth of 1 foot. The storage and stockpile areas should be large enough to provide a sufficient volume of materials for several days of operation in the event delivery from the sources is interrupted.

Equipment mobilized to the site would likely include conventional or specialized rototillers, (e.g., Geo-Con's BOSS system) for mixing the additives and setting agents into the surface soil, earth-moving equipment (e.g., front-end loaders and bulldozers), dump trucks, a mobile laboratory, and construction-support trailers.

Concrete decontamination pads would be constructed near the construction-support trailers. These pads would be used to decontaminate equipment used during in situ S/S activities.

In Situ S/S. Because of the large quantity of ditch requiring remediation, an in situ process capable of high throughput is preferred. At the rocket past area, the process would include a specialized rototiller that would be attached to a hydraulic excavator and manipulated as the vehicle moves along side the ditches. This system would work in conjunction with a mobile batch plant that would process a grout to be injected and mixed with the soil. It is anticipated that the grout reagent would be a 15 percent addition of Portland Type 1 Cement (see Figures 11-3, 11-14, and 11-15). The Nitroglycerine Pond area would be handled in the same manner, except that the excavator and rototiller may have to work off of crane mats if the pond areas are too soft to support the equipment weight. A portable batch plant would be set up on shore and the grout would be pumped to the work site. The desired treatment product would be in a durable pelletized or granular form. It is also possible for other S/S processes to produce other forms such as large blocks or monolithic slabs.

During in situ S/S, an exclusion zone would be established around the contaminated areas. S/S equipment would operate within this zone and would not leave without first undergoing decontamination. WDNR's Air Management Program would be contacted during the design phase to discuss appropriate measures for fugitive dust control.

**11.1.5.2 Cost Estimate.** The cost estimate for this alternative is shown in Table 11-10. The total cost for NG/RPA-SS5 is estimated to be $9,398,000.

**11.1.5.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 11-11. The in situ S/S and soil cover alternative would meet all of the remedial action objectives for surface soil at the Nitroglycerine Pond/Rocket Paste Area.

### 11.1.6 Comparative Analysis of Surface Soil and Sediment Alternatives

This subsection compares the relative advantages and disadvantages of the surface soil and sediment alternatives using the evaluation criteria. A comparative summary is provided in Table 11-12.

**11.1.6.1 Overall Protection of Human Health and the Environment.** Alternatives NG/RPA-SS3, -SS4, and -SS5 meet the remedial response objectives for potential human and environmental receptors, and protection of groundwater although at widely varying degrees of financial cost. Alternatives NG/RPA-SS1 and -SS2 do not meet response objectives.

**11.1.6.2 Compliance with ARARs.** Alternatives NG/RPA-SS3, -SS4, and -SS5 would comply with groundwater protection standards as required in the proposed NR720. Applicable location- and action-specific ARARs would be complied with regardless of which alternative is selected.

**11.1.6.3 Long-Term Effectiveness and Permanence.** Alternative NG/RPA-SS1 would be effective over the long term at limiting public access to site contaminants, but would not be effective in terms of restricting access by burrowing environmental receptors. Alternative NG/RPA-SS2 would be effective in restricting contact by both human and environmental receptors over the long term, as long as the soil cover is properly maintained, but would not protect groundwater. NG/RPA-SS3 and -SS5 would protect human and environmental receptors and groundwater by solidifying the soil. NG/RPA-SS4 protects human and environmental receptors and groundwater by moving the soil off-site to a landfill.

**11.1.6.4 Reduction of Toxicity, Mobility, and Volume.** None of the alternatives offer reduction in toxicity or volume of contamination because metals are the primary contaminants. Alternative NG/RPA-SS2 would offer a barrier to mobilizing influences, such as soil erosion. Alternatives NG/RPA-SS3, -SS4, and -SS5 offer the greatest degree of potential mobility reduction.

**11.1.6.5 Short-Term Effectiveness.** Alternative NG/RPA-SS1 would have very limited short-term impacts to site workers and the surrounding community. Alternative NG/RPA-SS2 also offers little impact to workers and the community because wastes would be covered in place, although the trucking of cover soils from an off-site location over local roads may be create a temporary nuisance.

Alternatives NG/RPA-SS3 and -SS4 offer an increased hazard to workers during remedial action because they include excavation and transport of contaminated soil. Alternative NG/RPA-SS5 offers an increased hazard to workers during remedial action because it includes mixing the soil in place with cement grout.

**11.1.6.6 Implementability.** There are no significant impediments to implementing alternatives NG/RPA-SS1, -SS2, and -SS4. The type and quantity of amendment required for NG/RPA-SS3 and -SS5 depends on the outcome of the treatability studies for soil stabilization. Stabilization/solidification is a proven technology which has been successfully implemented full scale at numerous sites.

**11.1.6.7 Cost.** Costs vary depending upon the technology chosen for the various remediation alternatives. NG/RPA-SS1 would cost $2,425,000, -SS2 would cost $2,995,000, -SS3 would cost $12,910,000, -SS4 would cost $34,743,000, and -SS5 would cost $9,398,000.

### 11.1.7 Preferred Alternative Selection

Based on the detailed analysis of the alternatives available for remediation of surface soil and sediment at the NG/RPA site, NG/RPA-SS5 (in-situ stabilization/ solidification) appears to be the most appropriate alternative. The remedial action objectives are met at the lowest cost. The ease of implementation and the minimization of contact with the contaminated soil makes NG/RPA-SS5 the most attractive alternative.

The large quantity of surface soil/sediment involved at the NG/RPA causes alternatives NG/RPA-SS3 (Excavation/Solidification/On-site Disposal) and -SS4 (Excavation/Off-site Disposal) to bear very high costs.

## 11.2 Surface Water Alternatives

The following three surface water remedial alternatives were retained for detailed analysis:

- Minimal Action (NG/RPA-SW1)
- Precipitation/Microfiltration (NG/RPA-SW2)
- Ion Exchange (NG/RPA-SW3)

Minimal Action serves as a baseline for the other surface water alternatives. Both the precipitation/microfiltration and ion exchange alternatives are designed to treat contaminated surface water using mobile treatment systems.

### 11.2.1 Alternative NG/RPA-SW1: Minimal Action

This subsection describes the minimal action alternative, provides a cost estimate, and evaluates the alternative using the seven evaluation criteria.

**11.2.1.1 Description.** The minimal action alternative is developed to assess impacts on human health and the environment if no remedial technologies were implemented. This alternative would take approximately one month to implement. Beneficial results would be seen immediately.

The key components of the alternative are:

- Fencing and warning signs
- Institutional controls
- Education programs
- Annual site inspection
- Surface water monitoring program
- Five-year site review

This (and other surface water) alternatives do not include a groundwater monitoring program because groundwater monitoring is a component of all surface soil/sediment alternatives. The key components of this alternative are described in the following paragraphs.

Fencing and Warning Signs. A 6-foot-high, chain-link fence with three-strand barbed wire would be installed to discourage entry to the Nitroglycerine, Overflow, and Rocket Paste Ponds. The fence would be installed along the perimeter of the NG/RPA as shown in Figure 11-11. The proposed fence would be approximately 6,000 linear feet, including swing gates across the entrances. The fence would enclose approximately 22 acres. Warning signs would be posted along the fence at 50-foot intervals and on entrance gates. This element would be unnecessary if the surface soil/sediment minimal action alternative is selected as that alternative includes site fencing that would enclose the ponds.

Institutional Controls. At present, the Army has no plans to designate the area within BAAP for residential or public use. This component of the minimal action alternative would be implemented if BAAP were to be decommissioned. Institutional controls in the form of deed and/or zoning restrictions would be needed to prohibit future land use. These controls would be drafted, implemented, and enforced in cooperation with state and local governments.

Educational Programs. This component involves conducting public meetings and presentations to keep the public informed of the site status. Site status refers to both the general condition of the site and remaining contaminant levels. In addition, informational mailings would be sent to community citizens who may utilize BAAP property for hunting or farming.

Annual Site Inspection. An annual site inspection would be conducted to check fence integrity. Repairs would be performed as needed.

Surface Water Monitoring Program. A surface water monitoring program would be implemented to monitor contaminant levels in the Nitroglycerine, Overflow, and Rocket Paste Ponds. The surface water monitoring program would involve collection of two samples each from the Nitroglycerine, Rocket Paste, and Overflow ponds. Samples would be analyzed for metals as described in WDNR, 1992. Monitoring frequency would be annually for the first five years, and once every five years thereafter.

Five-Year Site Review. The five-year site review is applicable to this alternative.

**11.2.1.2 Cost Estimate.** The cost estimate for this alternative is shown in Table 11-13. The total cost for NG/RPA-SW1 is estimated to be $349,000.

**11.2.1.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 11-14.

### 11.2.2 Alternative NG/RPA-SW2: Precipitation/Microfiltration

This subsection describes the precipitation/microfiltration alternative, provides a cost estimate for the alternative, and evaluates the alternative using the seven evaluation criteria.

**11.2.2.1 Description.** This alternative consists of removing and treating surface water from the Nitroglycerine, Overflow, and Rocket Paste Ponds, and discharging it to the main ditch. An estimated 5,000,000 gallons of surface water require treatment.

Key components of the alternative are:

- Treatability testing
- Site preparation and mobilization
- Bypass pumping and pumping to treatment facility
- Surface water treatment
- Confirmation sampling
- Discharge water to Main Ditch

This alternative would take approximately three months to implement. Beneficial results would be seen immediately.

Key components of this alternative are described in the following paragraphs.

Treatability Testing. Bench-scale treatability tests would be required to determine the most effective precipitation parameters such as pH, flow rate, and process train (e.g., hydroxide, carbonate, sulfide). Evaluation would consider criteria such as effective removal rates, treated water quality, and estimated volume of residual sludge.

Site Preparation and Mobilization. Mobile precipitation and microfiltration equipment would be mobilized on site and located adjacent to the Nitroglycerine Pond. Temporary piping would be installed from the Overflow and Rocket Paste Ponds to the treatment system, and from the treatment system to the discharge point at the Main Ditch. Figure 11-12 shows the site layout for surface water remediation.

Surface Water Pumping. To minimize surface water runoff into the NG and RP Ponds during remediation activities, the Main Ditch would be dammed both upstream and downstream of both ponds. As surface water collects upstream of each pond it would be pumped around the pond and back into the main ditch downstream of the dammed pond.

Treated water would be discharged downstream of the NG Pond and eventually pumped around the RP Pond.

Surface Water Treatment. Water would be pumped from the Nitroglycerine, Overflow, and Rocket Paste Ponds with trash pumps and flexible hose and treated using the trailer-mounted precipitation and microfiltration system. Treatment system flow is expected to be 50 gpm. In the typical precipitation and microfiltration treatment system, hydroxide/sulfide precipitation is utilized to achieve minimum solubility of metals and produce filterable-size particles. Following metals precipitation, the process stream is pumped through tubular membrane filtration modules at a high velocity. Water is forced through membrane pores while particles remain suspended in a recirculated stream (i.e., slurry). Turbulence in the slurry prevents particles form accumulating on membrane surfaces. A portion of the slurry is periodically removed from the system and dewatered with a filter press. Treated water would be discharged to the Main Ditch and bypass pumped around the Rocket Paste Pond. Filter cake produced from the dewatering process would require off-site disposal. After removal of the surface water from the ponds, the sediment remedial alternative chosen in Subsection 11.1 would be implemented.

Discharge Water to Main Ditch. After treatment the water would be pumped to a discharge point on the Main Ditch downstream of the Nitroglycerine Pond.

Confirmation Sampling. The on-site mobile laboratory would run tests on the treated surface water to ensure that pre-determined QA/QC criteria are being achieved. A sampling frequency (i.e., one sample for a given volume) would be specified. QA/QC criteria could include the following maximum remaining concentrations: AL-748 $\mu$g/L; CR-11 $\mu$g/L; CU-12 $\mu$g/L; FE-1,000 $\mu$g/L; MN-50 $\mu$g/L; PB-3.2 $\mu$g/L; ZN-110 $\mu$g/L.

**11.2.2.2 Cost Estimate.** The cost estimate for this alternative is shown in Table 11-15. The total cost for NG/RPA-SW2 is estimated to be $843,000.

**11.2.2.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 11-16.

### 11.2.3 Alternative NG/RPA-SW3: Ion Exchange

This subsection describes the ion exchange alternative, provides a cost estimate for the alternative, and evaluates the alternative using the seven evaluation criteria.

**11.2.3.1 Description.** This alternative consists of removing and treating surface water from the Nitroglycerine, Overflow, and Rocket Paste Ponds, and discharging it to the Main Ditch.

This alternative would take approximately three months to implement. Beneficial results would be seen immediately.

Key components of the alternative are:

- Treatability testing
- Site preparation and mobilization (see Subsection 11.2.2.1)
- Bypass pumping and pumping to treatment facility (see Subsections 11.2.2.1)
- Surface water treatment (see Subsection 11.2.2.1)
- Confirmatory sampling (see Subsection 11.2.2.1)
- Discharge water to Main Ditch (see Subsection 11.2.2.1)

The key components for this alternative are similar to NG/RPA-SW2 Precipitation/Microfiltration (Subsection 11.2.2) except the primary surface water treatment technology would be ion exchange. Microfiltration would be unnecessary with ion exchange. The other key components are described in the following paragraphs.

Treatability Testing. Bench-scale treatability tests would be required to determine the effectiveness of existing ion exchange resins on Nitroglycerine, Overflow, and Rocket Paste Pond surface water.

Surface Water Treatment. Water would be pumped from the Nitroglycerine, Overflow, and Rocket Paste Ponds with trash pumps and flexible hose and treated using a trailer-mounted ion exchange system. Treatment system flow is expected to be 50 gpm. In the typical ion exchange treatment system, water is filtered to remove insoluble debris and fed to ion exchange columns, operating in series, where selected resins remove dissolved ions (i.e., metals). When the primary column is saturated to the extent that it no longer achieves the required degree of metal removal (also known as breakthrough which can lead to the leakage of metals into the discharge stream), the column is regenerated with acid. During regeneration of the primary column, the process stream is fed through the secondary column to maintain continuous treatment. After the primary column is regenerated, it is returned to

service as the secondary column. Treated water would be discharged to the Main Ditch and bypass pumped around the Rocket Paste Pond. Regenerant containing dissolved metal ions is fed to a plate-out cell where metals are deposited electrolytically on stainless steel cathodes. When the metal reaches a thickness of ⅛ inch or more, it is stripped off as plates or sheets for disposal. Regenerant is strengthened with fresh acid and recycled to serve in the next regeneration cycle. After removal of the surface water from the ponds, the sediment remedial alternative chosen in Subsection 11.1 would be implemented.

**11.2.3.2 Cost Estimate.** The cost estimate for this alternative is shown in Table 11-17. The total cost for NG/RPA-SW3 is estimated to be $843,000.

**11.2.3.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 11-18.

### 11.2.4 Comparative Analysis of Surface Water Alternatives

This subsection compares the relative advantages and disadvantages of the surface water alternatives using the evaluation criteria. A comparative summary is provided in Table 11-19.

**11.2.4.1 Overall Protection of Human Health and the Environment.** There are no unacceptable excess human health risks posed by chemicals in surface water at this site.. Alternative NG/RPA-SW1 would not meet remedial action objectives for environmental receptors. With the exception of possibly HG, alternative NG/RPA-SW2 meets remedial action objectives. NG/RPA-SW3 may not be able to achieve environmental remedial action objectives due to breakthrough and leakage of metals.

**11.2.4.2 Compliances with ARARs.** Chemical-specific ARARs for Nitroglycerine Pond surface water are not available. Applicable location- and action specific ARARs would be complied with regardless of which alternative is selected.

**11.2.4.3 Long-Term Effectiveness and Permanence.** Alternative NG/RPA-SW1 would, by virtue of the fence, limit surface water contact by some of the larger semi-aquatic animals that frequent the ponds. Alternative NG/RPA-SW2 would permanently remove identified environmental risks to aquatic and semi-aquatic animals and groundwater. Because treated surface water may not attain RGs, NG/RPA-SS3 could result in residual risk to environmental receptors.

**11.2.4.4 Reduction of Toxicity, Mobility, and Volume.** Alternative NG/RPA-SW1 offers no reduction of toxicity, mobility, or volume of surface water chemicals. Alternatives NG/RPA-SW2 and -SW3 would both reduce mobility of site chemicals in surface water. Alternative NG/RPS-SW3 potentially achieves the greatest reduction in mobility because metals are bound in metal sheets with negligible potential for leaching.

**11.2.4.5 Short-Term Effectiveness.** Alternative NG/RPA-SW1 would have no significant short-term impact on site workers or the surrounding community. Remedial actions in Alternatives NG/RPA-SW2 and -SW3 pose no significant impacts to the community and to site workers, but aquatic and semi-aquatic populations using the ponds would be impacted during remediation. Additional impacts to water quality could occur during implementation of NG/RPA-SW2 because of the chemicals added to the process stream during precipitation.

**11.2.4.6 Implementability.** There are no significant impediments to implementing Alternatives NG/RPA-SW1, -SW2 or -SW3.

**11.2.4.7 Cost.** The two treatment alternatives would cost approximately the same at $843,000, while minimal action would cost $349,000.

### 11.2.5 Preferred Alternative Selection

Based on the detailed analysis of the alternatives available for remediation of surface water at the NG/RPA site, NG/RPA-SW2 (Precipitation/Microfiltration) appears to be the most appropriate alternative. Remediation costs would be reasonable. NG/RPA-SW3 (Ion Exchange) has the same approximate cost of implementation as NG/RPA-SW2, but would not be effective in metals removal to the levels prescribed by the RGs.

# 12.0 DETAILED ANALYSIS OF SETTLING PONDS AND SPOILS DISPOSAL AREA ALTERNATIVES

Remedial alternatives for soil remediation at Final Creek, the Settling Ponds and Spoils Disposal Area are evaluated in this section using seven of the nine evaluation criteria recommended in USEPA's RI/FS guidance (USEPA, 1988), as discussed in Subsection 1.7. The alternatives that are evaluated in this section were retained after initial screening of alternatives in Section 6.0.

This section presents a detailed evaluation of each of the remedial alternatives for soils and compares the relative advantages and disadvantages of each alternative using the evaluation criteria. Following alternative comparison, the recommended remedial alternative for soil is chosen. The recommended alternative is presented in Subsection 12.1.5.

## 12.1 SOIL ALTERNATIVES

The following alternatives were retained for detailed evaluation after the development and initial screening in Section 6.0:

- Minimal Action (SSP-SS1)
- Capping (SSP-SS3)
- Modified In Situ Stabilization/Solidification (S/S) and Soil Cover (SSP-SS7)

### 12.1.1 Alternative SSP-SS1: Minimal Action

This subsection describes the minimal action alternative, provides a cost estimate, and evaluates the alterative using the seven evaluation criteria.

**12.1.1.1 Description**. The minimal action alternative is developed to assess impacts on human health and the environment if no remedial actions are implemented. Components of this alternative are as follows:

- institutional controls
- educational programs, including public meetings and presentations
- monitoring program with five-year site reviews

The key components of this alternative are discussed in the following paragraphs.

Institutional Controls. At present, the Army has no plans to designate areas within BAAP for residential or public use. This component of the minimal action alternative is included only for consideration in the event the Army should decommission the site. Institutional controls in the form of deed or zoning restrictions would be implemented as necessary to restrict residential or public use of the site. The legal ramifications associated with instituting property deed restriction will need to be coordinated with appropriate Army officials, WDNR, and the City of Baraboo.

Educational Programs. This component includes conducting public meetings and presentations to keep the public informed of the site status. Site status refers to both the general condition of the site and remaining contaminant levels.

Monitoring Program. Under CERCLA 121c, remedial action that results in hazardous substances, pollutants, or contaminants remaining on site must be reviewed at least every five years. Data collected during the monitoring program aid in determining whether human health and the environment are protected. This review may initiate remedial action, if appropriate. The monitoring program would be implemented to evaluate the potential migration of surface soil contaminants from Final Creek, the Settling Ponds, and Spoils Disposal Areas to the groundwater. The approximate areal extent of contamination is shown on Figure 12-1.

The groundwater monitoring program to be implemented will be a continuation of the ongoing monitoring program defined in the October 30, 1992 "Modification of Conditional Plan Approval of In-field Conditions Report" (WDNR, 1992) attached in Appendix D-1. The purpose of this BAAP-wide sampling and analysis program is to monitor contamination migration and assess future environmental impacts. The monitoring locations, analytical parameters, and monitoring frequency pertinent to the Settling Ponds and Spoils Disposal Area are presented in Table 12-1.

**12.1.1.2 Cost Estimate.** For cost-estimating purposes, the following assumptions were made:

- institutional controls $10,000
- educational programs $5,000 per year for 30 years
- five-year site reviews $10,000 each
- groundwater monitoring of 27 wells $161,000 per year for 30 years

The cost estimate for this alternative is shown in Table 12-2.

**12.1.1.3 Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 12-3.

**12.1.2 Alternative SSP-SS3: Capping**

This subsection describes the capping alternative, provides a cost estimate for the alternative, and evaluates the alternative using the seven evaluation criteria.

**12.1.2.1 Description.** Multi-layered caps that meet the USEPA's guidance criteria for final cover systems would be installed over Final Creek, the Settling Ponds and Spoils Disposal Area. This alternative is designed to meet all of the remedial action objectives for soil. For the purposes of this FS, it has been assumed that each pond and spoils area will receive a separate cap. The approximate areal extent of contamination and caps are shown in Figures 12-1 and 12-2. During final design, it may be appropriate to combine certain areas under one cap to promote drainage and/or reduce cap material volumes. The caps over the Settling Ponds would total approximately 87 acres; those over the spoils areas would cover about 16 acres. The key components of the alternative are:

- institutional controls
- site preparation and mobilization
- contaminated soil delineation
- cap construction
- surface water management
- post-closure maintenance
- monitoring program and five-year site reviews (see Subsection 12.1.1.1)

The groundwater monitoring program with five-year site reviews is identical to that discussed in Subsection 12.1.1.1. Other key components are discussed in the following paragraphs.

Site Preparation and Mobilization. A laydown and stockpile area for cap soils and geosynthetic materials would be established south of Settling Ponds 2 and 3 (Figure 12-2). The area would be large enough to provide sufficient volume for several days of filling and grading operations in the event delivery from the sources is interrupted. A parking area for a mobile analytical laboratory, construction-support trailers, and heavy equipment would be prepared by grubbing, grading, and placing gravel to a minimum thickness of 1 foot.

Equipment mobilized to the site would include earth-moving equipment (i.e., excavators, front-end loaders, and bulldozers), dumptrucks, and construction-support trailers.

A borrow study would be required to identify suitable soils to use in the cap components.

Contaminated Soil Delineation. It is estimated the entire areas shown in Figure 12-1 will be covered, but samples should be taken prior to placement of the cover to confirm contamination areal extent. SN, PB, 24DNT, and 26DNT are the primary soil contaminants in Final Creek and the Settling Ponds based on the risk evaluation with secondary contaminants consisting of DEP, DPA, CPAH, AL. 26DNT is generally co-located with 24DNT, consequently, the areas requiring remediation would be delineated using the RGs for SN (10 mg/kg), PB (30 mg/kg), and 24DNT (2.5 mg/kg). Based on the risk characterization, ZN, PB, and SN are the primary surface soil contaminants in the Spoils Disposal sites, with secondary contaminants consisting of 24DNT, DPA, and NG. Soils requiring delineation in the Spoils Disposal Areas would be delineated using the RG for ZN (81.3 mg/kg) and PB (30 mg/kg) (no remediation goal exists for SN).

Cap Construction. For each pond or spoils disposal site, the entire area within the boundaries established during the contaminated soil delineation would be covered. The cap system would be constructed of the following materials (from the top down):

1 foot vegetation/topsoil layer
2 foot common borrow layer
geotextile filter fabric
1 foot sand drainage layer
60-mil geomembrane
2 foot compacted clay layer

common borrow layer

Figure 12-3 illustrates a typical cap system cross-section.

A common borrow subgrade layer would be used to bring Final Creek, the Settling Ponds, and Spoils Disposal Sites to an appropriate grade to promote surface water drainage. A 2-foot layer of clay, compacted to achieve a hydraulic conductivity of $1x10^{-7}$ cm/sec or less would then be placed over the subgrade layer. During the design stage, an alternative hydraulic barrier such as a geosynthetic clay liner may be considered in place of the compacted clay.

Following placement of the clay, a 60-mil geomembrane would be placed over the entire clay layer. A 1-foot layer of drainage sand would be placed over the geomembrane to minimize the time infiltrated water is in contact with the geomembrane and, therefore, reduce the potential for water to reach the contaminated soils. The hydraulic conductivity of the drainage sand would be $5x10^{-3}$ cm/sec, or greater. A geotextile filter fabric would be placed over the drainage sand to prevent the migration of fines from the common borrow and topsoil layers into the drainage layer. A 2-foot layer of common borrow would be placed and compacted above the filter fabric. The 2-foot layer of common borrow, in conjunction with the 1-foot layer of topsoil would be used to protect the hydraulic barriers (geomembrane and compacted clay) from burrowing animals and freeze/thaw conditions. The topsoil would be fertilized and seeded to provide a good vegetative cover.

The cap soil would be transported either directly from the borrow source, or from an on-site stockpile area to the contaminated areas. The soils would be spread, graded, and compacted using conventional construction equipment (e.g., tracked bulldozer, vibratory or sheepsfoot roller). During construction, an on-site laboratory may be established to test the soil materials for quality assurance/quality control. A total of approximately 1,800,000 cubic yards of cover soils would be needed to construct the caps over Final Creek, the Settling Ponds and the Spoils Disposal Areas.

Surface Water Management. Each cap will be graded to no less than 3 percent to promote runoff over the area. Actual slopes would be selected to account for subsidence that may occur as a result of consolidation of the sediment in the Settling Ponds and Spoils Disposal Area. Perimeter sideslopes of the cap would be limited

to a maximum slope of 3H:1V (horizontal to vertical) in order to minimize cover erosion.

Drainage ditches would be constructed around the perimeter of the capped areas to divert surface water run-off and reduce soil cover erosion. The ditches would be designed to convey runoff from a 25-year storm. The existing capacity of the Settling Ponds to convey wastewater need not be maintained after implementation of the selected alternative because in the event of plant mobilization, these areas will not receive industrial process effluent. Instead, a discharge pipe will carry effluent directly to the Wisconsin River (Fordham, 1992).

Post-Closure Monitoring/Maintenance. Post-closure monitoring and maintenance would include visual inspections and, if necessary, repairs to the cover. The caps would be inspected annually for damage to the caps due to such things as erosion, subsidence, or animal burrows. Subsequent repairs such as minor regrading or revegetating would take place if damage is identified. Cover vegetation would be mowed on an annual basis to prevent trees from taking root and damaging the covers.

**12.1.2.2 Cost Estimate.** For cost-estimating purposes, the following assumptions were made:

- 3-acre stockpile area
- 0.5-acre parking area
- $90,000 for delineation of contaminated soils
- 1,220,000 cubic yards of common borrow
- 268,000 cubic yards of clay
- 400,000 square yards of geomembrane
- 400,000 square yards of geotextile
- 134,000 cubic yards of drainage sand
- 134,000 cubic yards of topsoil
- 17,100 linear feet of drainage ditch constructed around the soil covers
- five-year site reviews $10,000 each
- annual inspections at 8 hours each
- groundwater monitoring of 27 wells $161,000 per year for 30 years

The cost estimate for this alternative is shown in Table 12-4. Cost and material usage are provided in Appendices G.1 and G.2, respectively.

**12.1.2.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 12-5. The capping alternative would meet all of the remedial action objectives for soil at Final Creek, the Settling Ponds, and the Spoils Disposal Area.

### 12.1.3 Alternative SSP-SS3: Modified In Situ Stabilization/Solidification and Soil Cover

This subsection describes the modified in situ S/S and soil cover alternative, provides a cost estimate for the alternative, and evaluates the alternative using the seven evaluation criteria.

**12.1.3.1 Description.** The modified in situ S/S and soil cover alternative consists of (1) excavating subsurface soils exceeding RGs from the central portion of Settling Pond 1 (to a depth of approximately 10 feet bgs) and the top 1 foot of surface soil at Spoils Disposal Sites 1 through 4 and stockpiling on site, (2) backfilling the excavation at Settling Pond 1 with clean borrow soil, (3) stabilizing the surface soils using in situ equipment at Final Creek, the Settling Ponds and the Spoils Disposal Sites to provide stable, granular or monolithic residual soil, (4) using in situ S/S equipment to treat successive lifts of the contaminated stockpiled soil within the limits of the Settling Ponds, (5) and placement of at least 2.5 feet of cover soil. Item (1) above is necessary because soil exceeding the RGs in Settling Pond 1 and Spoils Disposal Sites 1 through 4 are expected to be deeper than the depth capability of in situ S/S equipment. The purpose of the 2.5 feet of cover (minimum) is to bury the treated soil below anticipated frost penetration (ABB-ES, 1993a), and to promote site drainage away from the site. Figure 12-4 shows the estimated areal extent of the treatment and covers. The alternative would be designed to meet the remedial action objectives for soil. The key components of the alternative are:

- institutional controls
- treatability testing
- mobilization and site preparation
- contaminated soil delineation

- excavation of subsurface soil (likely only from Settling Pond 1) and the top 1 foot of surface soil from Spoils Disposal Sites 1 through 4 and stockpiling on site
- dozing the contaminated surface soils on the side slopes of Final Creek and the Settling Ponds into flatter areas for ease in stabilization
- in situ S/S
- S/S of contaminated soils in lifts by in situ S/S equipment
- confirmatory sampling
- soil cover construction
- surface water management (see Subsection 12.1.2.1)
- post-closure maintenance (see Subsection 12.1.2.1)
- monitoring with five-year site reviews (see Subsection 12.1.1.1)

Surface water management, and post-closure maintenance for this alternative would be similar to those discussed in Subsection 12.1.2.1. Contaminated soil delineation would be similar to that developed in Subsection 12.1.2.1, except that the guidelines would also be applied to subsurface soil. Soil cover construction for this alternative would be similar to that discussed in Subsection 12.1.2.1, except that a 2.5-foot minimum soil cover (plus common borrow fill that might be needed for grading purposes) would be required instead of the cap for Alternative SSP-SS3. The monitoring program for this alternative is identical to that discussed in Subsection 12.1.1.1. Other key components are discussed in the following paragraphs.

Treatability Testing. A bench-scale treatability test would be required to determine the most effective additives and setting agents for treating Settling Pond, Spoils Disposal, and Final Creek soils. The bench test would also determine the proper ratio of additives/setting agents to contaminated soil. Analyses of test samples before and after treatment would include TCLP, and tests to determine uniformity of the treated product and its long-term endurance potential.

A pilot-scale treatability test would be required to determine the most cost-effective method for mixing the additives and setting agents into the soil. A small plot would be prepared at the Settling Ponds and Spoils Disposal Site for conducting the pilot test. Selected types of equipment would be tested for their potential to produce homogenous mixing at high throughput rates. Additionally, pilot tests would determine whether dry (i.e., powder) or wet (i.e., slurry) application of the additives/setting agents is appropriate for the equipment used during in situ S/S. Analyses during pilot tests would be similar to those conducted during the bench tests.

Site Preparation and Mobilization. A stockpile area for storing cover soil (i.e., common borrow and topsoil) would be established south of Settling Ponds 2 and 3 (Figure 12-4). A covered storage area for S/S additives and settling agents and a parking area for a mobile laboratory, construction-support trailers, and heavy equipment would be prepared south of Settling Ponds 2 and 3 by grubbing, grading, and placing gravel to minimum thickness of 1 foot. A second stockpile area for contaminated subsurface soils (Settling Pond 1) and surface soil (Spoils Disposal Sites 1 through 4) would be constructed at a location south of Settling Pond 1. The storage and stockpile areas should be large enough to provide a sufficient volume of materials for several days of operation in the event delivery from the sources is interrupted.

Equipment mobilized to the site would likely include conventional or specialized rototillers for mixing the additives and setting agents into the surface soil, earth-moving equipment (e.g., backhoes, front-end loaders, and bulldozers), dump trucks, a mobile laboratory, hoppers for storage of S/S additives and setting agents, and construction-support trailers.

A concrete decontamination pad would be constructed near the construction-support trailers. This pad would be used to decontaminate equipment used during in situ S/S activities and excavation activities. The pad would be designed to collect decontamination water in a sump, and to pump the water into a storage tank.

Contaminated Soil Delineation. Although contaminated surface soil at Final Creek, the Settling Ponds, and the Spoils Disposal Area were delineated during the RI, surface soils near the limits of the Ponds and Disposal Areas were not well delineated during the RI.

During separate site investigations, subsurface soils below 2 feet bgs were investigated at only one location at Final Creek (ABB-ES, 1993a) and seven locations at the Settling Ponds (EEI, 1981). The subsurface soil sampling and testing at the Settling Ponds were performed on composited samples collected over ranges of up to 15 feet, which made delineation of subsurface soil contamination difficult. No subsurface soil sampling was performed at the Spoils Disposal Area sites. The composited sample results at the Settling Ponds indicated concentrations of 24DNT and DEP above RGs at S1202 and S1203 in Settling Pond 1 at a reported depth of 3 feet (likely composited over a range of 3 to 15 feet). No other subsurface soil exceedances were observed. Therefore, additional contaminated surface and subsurface soil delineation should be performed at each pond and disposal site prior to final remedial design. It has been assumed for the purposes of this alternative that contamination to a depth of 10 feet near S1202 and S1203 exists which requires treatment.

SN, PB, and 24DNT are the primary soil contaminant in Final Creek and the Settling Ponds based on the risk evaluation. Consequently, the areas requiring remediation would be delineated using the RGs for SN (10 mg/kg), PB (30 mg/kg), and 24DNT (2.5 mg/kg). Based on the risk characterization, ZN, PB, and SN are the primary soil contaminants in the Spoils Disposal Areas. Soils requiring delineation in the Spoils Disposal Areas would be delineated using the RG for ZN (81.3 mg/kg) and PB (30 mg/kg). A mobile laboratory would be on site to provide quick analysis and results of the soil sample during delineation.

Excavation and Stockpiling of the Contaminated Soil, and Backfilling of Excavations. Concurrent with the contaminated subsurface soil delineation in Settling Pond 1, contaminated subsurface soil would be excavated and stockpiled on site for future treatment. The amount removed would be identified by the on site contamination delineation. It has been assumed that a total of 10 feet bgs of soils would require excavation and future treatment at Settling Pond 1 over approximately one-half of the pond area. Excavation would be conducted with standard excavation and earthmoving equipment and stockpiled south of Settling Pond 1 (see Figure 12-4).

The top 1 foot of surface soils would be excavated at Spoils Disposal Sites 1 through 4 (a total of approximately 3 feet of contaminated soil exists) and placed in the stockpile near Settling Pond 1 for future treatment. This will allow the bottom 2 feet of contaminated soils to be stabilized with in situ equipment.

The excavation made at Settling Pond 1 for the removal of contaminated subsurface soil would be backfilled with clean borrow fill to allow sufficient surface area for stabilization of the stockpiled contaminated soil. During final design, the contractor may opt to stabilize the stockpiled material on the remaining portions of Settling Pond 1 and/or on Settling Ponds 2 through 4, and backfill the Pond 1 excavation with stabilized soil.

In Situ S/S. Because of the large area (i.e., approximately 87 acres) requiring remediation, an in situ process capable of high throughput is preferred. The process would include conventional or specialized rototillers or graders that could be either pulled behind heavy equipment or attached to heavy equipment (e.g., backhoe) and manipulated as the vehicle moves along a pre-designated route. Depending upon the results of pilot-testing at the site, the surface soil may be tilled before and after application of the S/S additives, or tilled during application of the additives. The desired treatment product would be a shallow, uniform monolith or granular product which would be durable and resistant to infiltration and leaching. The treated soil would be allowed to cure approximately two to three days prior to construction of the soil cover. A more detailed discussion of the S/S process is discussed in the following paragraphs.

Several contractors, including Geo-Con, Inc., have equipment that can be used for in situ S/S of surface soil. The method proposed by Geo-Con is explained here as an example of in situ S/S.

Geo-Con would use a modified version of a CAT SF 250 road stabilizer machine to apply a pre-determined mixture of water and cement additives to the soil. The SF 250 is similar to a large farm tiller that has a series of harrows suspended from a carriage. The harrows have hollow stems that apply the metered cement-water mixture in precise amounts. The cement and water is pumped from two trucks that follow the SF 250 and keep pace with the application.

The SF 250 system is capable of stabilizing soils to a depth of 10-12 inches bgs. Geo-Con would propose stabilizing the upper ten inches of soil first. A motor grader would follow behind the SF 250 and push the stabilized material into windrows. The motor grader's blade would be set to only excavate the upper eight inches of stabilized material to allow for an overlap on the second pass to ensure complete coverage. The consistency of the stabilized material would be granular and the material would be easily handled by earth-moving equipment.

The SF 250 would then make the second pass over the contaminated area and stabilize the underlying layer of soils. Once the bottom layer is stabilized, the motor grader would push back the first layer of stabilized soils and regrade the site.

Geo-Con would set up a portable cement batch plant on site to provide storage and support to the stabilization activities. The estimated throughput using the proposed Geo-Con method is approximately 1,000 cubic yards of treated soil per day.

Some portions of contaminated surface soil in pitted areas (Final Creek or Spoils Disposal Areas) might be treated using a backhoe equipped with a boom extension. The backhoe bucket would place and mix S/S powder or slurry into the soils on the bottom and sides of the pits.

During in situ S/S, an exclusion zone would be established around the contaminated areas. S/S equipment would operate within this zone and would not leave without first undergoing decontamination.

S/S of Excavated Contaminated Soil. Because of the large volume (213,000 cubic yards from Settling Pond 1 and 19,000 cubic yards from Spoils Disposal Area 1 through 4) requiring remediation, an in situ process capable of high throughput is preferred. The process would be performed using in situ S/S equipment, and would consist of a similar process used for in situ S/S. Additional excavation and earthmoving equipment would be required to place the contaminated soil in lifts. As with the in situ process, treatment would include conventional or specialized rototillers that could be either pulled behind heavy equipment or attached to heavy equipment (e.g., backhoe) and manipulated as the vehicle moves along a pre-designated route. Depending upon the results of pilot-testing at the site, the surface soil may be tilled before and after application of the S/S additives, or tilled during application of the additives. The top layer of the treated soil would be allowed to cure approximately two to three days prior to construction of the soil cover.

During this process, the exclusion zone would be maintained around the contaminated areas. S/S and excavation and earthmoving equipment would operate within this zone and would not leave without first undergoing decontamination.

Confirmatory Sampling. The on-site mobile laboratory would run tests on the treatment product to ensure that predetermined QA/QC criteria are being achieved.

QA/QC criteria would probably include TCLP limits, degree of mixing, permeability, and unconfined compressive strength (if the product is monolithic).

Soil Cover Construction. The treated soil would be covered. The soil cover system would consist of a compacted 2-foot (minimum) common borrow soil layer under a 6-inch layer of topsoil seeded to establish a vegetative cover. The 2.5-foot soil cover is necessary to bury the stabilized soil beneath the 30-inch bgs frost penetration and protect it from freeze and thaw cycles (ABB-ES, 1993a). Additional fill would be placed as necessary to provide positive grading and to direct surface water away from the stabilized area. A schematic cross-section of the covered stabilized soil is shown in Figure 12-5.

Soil cover material would be transported either directly to the construction sites or from the on-site stockpile to the sites. The cover would be spread and graded using conventional construction equipment (e.g., tracked bulldozer). An estimated 889,000 cubic yards of common borrow and 67,000 cubic yards of topsoil would be required for cover construction.

**12.1.3.2 Cost Estimate and Sensitivity Analysis.** For cost-estimating purposes, the following assumptions were made:

- two 3-acre stockpile areas
- 0.5-acre parking area
- 50 ft. x 100 ft. storage building
- concrete decon pad
- 221,000 for delineation of surface and subsurface soils
- 87-acre in situ S/S and soil cover area (2 feet deep)
- 260,750 cubic yards of soil requiring in situ S/S
- 232,000 cubic yards of subsurface and surface soil requiring excavation from in Settling Pond 1 and Spoils Disposal Sites 1 through 4
- 237,000 cubic yards of soil requiring in S/S
- $45 per cubic yard for in situ S/S
- 889,000 cubic yards of common borrow
- 67,000 cubic yards of topsoil
- 17,100 feet of drainage ditch
- five-year site reviews $10,000 each
- eight-hour annual inspection
- groundwater monitoring of 27 wells $161,000 per year for 30 years

The cost estimate for this alternative is shown in Table 12-6. Cost and material usage are provided in Appendices G.1 and G.2, respectively.

**12.1.3.3 Remedial Alternative Evaluation.** The assessment of this alternative using the evaluation criteria is presented in Table 12-7. The modified in situ S/S and soil cover alternative would meet the remedial action objectives for soil at Final Creek, the Settling Ponds and Spoils Disposal Area.

### 12.1.4 Comparative Analysis of Soil Alternatives

This subsection compares the relative advantages and disadvantages of the soil alternatives using the evaluation criteria. A comparative summary is provided in Table 12-8.

**12.1.4.1 Overall Protection of Human Health and the Environment.** Although Alternative SSP-SS1, Minimal Action, potentially protects human health by restricting invasive activities, no remedial activities would be implemented for protection of groundwater caused by leaching or for protection of terrestrial receptors. Alternative SSP-SS3, Capping, includes both restricting invasive activities and provides a physical barrier between the contaminated soil and potential human and ecological receptors. The primary purpose of the caps would be to reduce leachate generation and protect groundwater quality. Therefore, Alternative SSP-SS3 would provide a high potential to protect human health, terrestrial receptors and groundwater. Alternative SSP-SS7 provides protection to human health, ecological receptors, and groundwater similar to that provided by SSP-SS3. Groundwater would be protected by stabilizing the contaminants in the soil into a solidified granular or monolithic mass that is resistant to leaching. Potential receptors would also be protected by restricting invasive activities and placement of a 2.5 foot cover. Although each of the two treatment alternatives (SSP-SS3 and SSP-SS7) would eliminate risk to environmental receptors, it is not clearly understood what detrimental impact to the local mammal population would be introduced by placing a soil cover or cap and/or solidifying surface soils over an 87-acre area at the site.

**12.1.4.2 Compliance with ARARs.** Chemical-specific ARARs have not been promulgated for the contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater are contained in the proposed Chapter NR 720 and are being applied to BAAP soil remediation. Because soil contaminants would not be removed or destroyed, Alternatives SSP-SS1, SSP-SS3, and SSP-SS7

would not comply with pathway-specific numeric standards contained in the proposed Chapter NR 720. However, capping used in Alternative SSP-SS3 could be designed to achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of human health and groundwater. The performance standard would include eliminating the availability of contaminant concentrations which exceed numeric clean-up standards for protection of human health and preventing contaminant concentrations which exceed numeric clean-up standards for protection of groundwater from degrading groundwater quality. Location-specific ARARs do not apply to SSP-SS1 because no remedial action would be taken. Location-specific ARARs may apply to some components of SSP-SS3 and SSP-SS7, particularly if the contaminated soil delineation falls within a designated wetland. If so, the proper permits would be obtained prior to construction. Each of the two treatment alternatives would meet action-specific ARARs.

**12.1.4.3 Long-term Effectiveness and Permanence.** Alternative SSP-SS1 does not effectively meet remediation goals. Alternatives SSP-SS3 and SSP-SS7 would effectively meet remediation goals assuming proper maintenance and institutional controls are executed. With proper maintenance, a cap or stabilized soil with soil cover should be reliable for in excess of 50 years.

Residual risk posed by site chemicals to ecological receptors is essentially eliminated by the two soil treatment alternatives, but long-term detrimental impacts to existing mammal populations from soil covers and stabilization/solidification actions must be considered.

**12.1.4.4 Reduction in Toxicity, Mobility, and Volume.** None of the alternatives considered reduce the toxicity or volume of the chemicals located in soils at the site. Mobility of site chemicals would be restricted by the SSP-SS3 (significant reduction of infiltration and leaching) and SSP-SS7 (significant reduction of leaching by stabilization). Although the mobility of the contaminants would be reduced in SSP-SS3, the volume of contaminated soil would increase by 20 to 30 percent.

**12.1.4.5 Short-Term Effectiveness.** Alternative SSP-SS1 provides no response action; therefore, threats to the community and site-worker health would not be encountered during implementation. Alternative SSP-SS3 would not involve invasive activity that would further expose contaminated soil; therefore, because there are no risks to the community at present, none are expected during implementation. Alternative

SSP-SS7 would involve invasive activity during excavation of contaminated soil for future S/S. Dust control and decontamination procedures would be required to reduce the potential for worker exposure. Low risks to the community would be expected during implementation of SSP-SS7. Appropriate on-site erosion control measures would be employed during implementation of alternatives SSP-SS3 and SSP-SS7 to reduce risks to the environment and community.

**12.1.4.6 Implementability.** Alternative SSP-SS1 includes implementation of a groundwater monitoring program and institutional controls if the Army were to return the facility to the public. The groundwater monitoring program included in SSP-SS1 is currently being implemented by Olin. Contractors with health and safety training are readily available for the construction of the cap and cover systems proposed in Alternatives SSP-SS3 and SSP-SS7. Cap and cover soils are believed to be available, in the quantities required, within a 30-mile radius of BAAP. Several sources would need to be utilized. Geotechnical contractors are available to provide in situ S/S services.

The equivalent of approximately 100,000 heavy truckloads (1,800,000 c.y. @ 18 c.y. per truck) would be required to deliver cover soils to the site during implementation of SSP-SS3 and 53,111 truckloads for SSP-SS7. Resulting off-site impacts of physical damage to local roads, noise annoyance, air pollution caused by diesel fumes, and safety hazards associated with increased traffic should be considered. Other possible off-site adverse affects to the environment would be dust, water-borne sediment erosion, and unpleasant aesthetics created by off-site soil mining operations.

**12.1.4.7 Cost.** Alternative SSP-SS1 has a 30-year present worth cost of $2,859,000. The 30-year present worth cost for Alternative SSP-SS3 to $33,797,00 and for Alternative SSP-SS7 is $67,492,000.

### 12.1.5 Preferred Alternative Selection

Alternative SSP-SS7, Modified In Situ S/S with Soil Cover is selected as the preferred alternative for soil remediation at Final Creek, the Settling Ponds, and the Spoils Disposal Sites. The soil stabilization is anticipated to immobilize contaminants by entrapment in a stable, granular or monolithic soil-reagent mixture. This alternative will achieve performance standards that meet the intent of proposed Chapter NR 720. Alternative SSP-SS7 has a high potential for protecting human health and groundwater, and with the soil cover will provide protection of terrestrial

receptors. Provided the cover is maintained, the stabilized soil should be reliable for in excess of 50 years. Although Alternative SSP-SS3 also should achieve performance standards that meet the intent of proposed Chapter NR 720, and has a high potential for protecting human health and groundwater, it does not provide an "active" and more permanent treatment method that removes or stabilizes/immobilizes the contaminants.

# 13.0 DETAILED ANALYSIS OF SOUTHERN OFF-POST AREA ALTERNATIVES

Remedial alternatives for groundwater remediation at the Southern Off-Post Area are evaluated in this section using evaluation criteria recommended in USEPA's RI/FS guidance (USEPA, 1988b). These criteria serve as the basis for the detailed analysis. The criteria are described in Subsection 1.7. The alternatives that are evaluated in this section were retained after initial screening of alternatives in Section 7.0.

Following the detailed analysis of remedial alternatives, the relative advantages and disadvantages of each alternative are compared using the evaluation criteria. Comparison of the alternatives leads to the selection of the recommended remedial alternative for groundwater remediation at the Southern Off-Post Area. The recommended remedial alternative is presented in Subsection 13.5. The following three groundwater remedial alternatives were retained for detailed analysis:

- Minimal Action (SOPA-GW1)
- Air Stripping (SOPA-GW2)
- Carbon Adsorption (SOPA-GW3)

Minimal Action was retained because it would meet the stated remedial objectives, as would the other two alternatives. SOPA-GW2 and SOPA-GW3 are designed to intercept, extract, and treat the Southern Off-Post Area contaminant plume using a proposed treatment facility located off-post.

For alternatives SOPA-GW2 and SOPA-GW3, three groundwater extraction scenarios were evaluated. The groundwater extraction scenarios provide a range of estimated cleanup times. The estimated cleanup times depend upon groundwater, interception, extraction, and treatment at the BAAP boundary, which is proposed in Subsection 9.4 for the Propellant Burning Ground contaminant plume. Containment and treatment of the on-base contaminant plume would prevent any further contamination of Southern Off-Post Area groundwater.

Alternatives SOPA-GW2 and SOPA-GW3 share the following components:

- site preparation and mobilization;
- groundwater extraction system construction;

- gravity discharge effluent pipe construction;
- treated groundwater discharge; and
- groundwater monitoring.

Because the above components are identical between the treatment alternatives, they will not be a factor in the comparative analysis between alternatives SOPA-GW2 and SOPA-GW3. However, all components will be described and included in the detailed analysis.

Alternatives SOPA-GW2 and SOPA-GW3 differ in that they contain different treatment technologies and treatment trains. Comparison will be largely based on the merits of their respective treatment technologies/trains. All the remedial alternatives are described and evaluated in detail in the following subsections.

## 13.1 ALTERNATIVE SOPA-GW1: MINIMAL ACTION

This subsection describes the minimal action alternative, provides a cost estimate, and evaluates the alternative using the evaluation criteria.

### 13.1.1 Description

The following components comprise this alternative:

Groundwater Monitoring. Continue the ongoing monitoring program defined in the October 30, 1992 "Modification of Conditional Plan Approval of In-field Conditions Report" (WDNR, 1992) attached as Appendix D.1. The purpose of this on-post and off-post sampling and analysis program is to monitor contamination migration. In the event there is a change in aquifer contaminant distribution which would affect residential and/or public water supply wells, actions outlined in the Off-Post Contingency Plan would be implemented. The Off-post Contingency Plan Report for BAAP was prepared by ABB-ES as a component of Task Order 1 of Contract DAAA15-91-D-0008 with the USAEC. The report outlines actions that will be taken if migration of site-related contaminants adversely affects off-post residential water supplies. The USAEC authorized preparation of the Off-Post Contingency Plan to enable a rapid response to protect public health in the possible, though unlikely event, site-related contaminants migrate to public and private water supplies. The monitoring locations, analytical parameters, and monitoring frequency pertinent to the Southern Off-Post Area are presented in Table 13-1. The locations for the

Southern Off-Post Area monitoring wells identified in Table 13-1 are shown in Figure 13-1.

The USEPA batch flushing model was used to estimate Southern Off-Post Area aquifer cleanup times. The model assumes there are no continuing sources of contamination, as would be effectively achieved by the BAAP boundary control wells referenced in Subsection 9.4 for the Propellant Burning Ground. The model results depend on soil bulk density, organic carbon partition coefficient of the contaminant, organic carbon fraction in the aquifer, and aquifer porosity. The organic carbon partition coefficient for TRCLE was used in the model to be conservative because it is the least mobile of the three Southern Off-Post Area organic contaminants. Maximum concentrations for CCL4 at the BAAP boundary were also used in the model to be conservative. Calculations and assumptions are contained in Appendix H.1.

For purposes of the FS, an approximate cleanup time of 66 years was estimated as the time required for complete flushing of the aquifer.

Institutional Controls. Implement institutional controls in the form of deed restriction, zoning, or both. The controls would restrict use of groundwater in the Southern Off-Post Area. Deed restrictions could include limiting groundwater use to irrigation of crops and may occur voluntarily or by using governmental powers of eminent domain. Zoning changes would probably require participation, approval, and enforcement by the Township. Any institutional controls must be enforced to be effective. The time period to implement any type of institutional control is uncertain. The legal cost to implement this alternative is unknown.

Educational Programs. Conduct periodic public meetings and presentations to increase public awareness. This would help keep the public informed of the site status, including both its general condition and remaining contaminant levels. This could be accomplished by conducting annual presentations at public meetings involving the appropriate regulatory agency. Findings from the monitoring program for the previous year could be presented and discussed at the hearing.

Individual briefings at farms with contaminated irrigation wells could be conducted to inform farm workers of the precautions that can be taken to reduce their exposures to contaminated groundwater. Instructions on the proper use of protective equipment could be provided.

Five-Year Site Reviews. Under CERCLA 121c, any remedial action (or lack thereof) that results in contaminants remaining on site must be reviewed at least every five years. Data collected during the groundwater monitoring program would provide information for these reviews. The reviews would determine whether human health and the environment are protected. If appropriate, remedial actions may be initiated.

### 13.1.2 Cost Estimate

The present-worth of this alternative is estimated at $2,889,000. This includes a capital cost of $50,000 for education plan preparation, no indirect costs, and a total annual present-worth operating cost of $2,839,000 (Table 13-2). Yearly costs for the ongoing groundwater monitoring program are from Olin Corporation (Olin, 1993). A 30-year monitoring program is used for costing purposes.

Operating expenditures include installation costs for replacement of monitoring wells during year 16 of the monitoring program.

### 13.1.3 Alternative Evaluation

The assessment of this alternative against the evaluation criteria is presented in Table 13-3.

## 13.2 ALTERNATIVE SOPA-GW2 AIR STRIPPING

This subsection describes the Air Stripping alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the seven evaluation criteria. This alternative was evaluated with respect to three groundwater extraction scenarios, with contaminant plume estimated cleanup times of 61, 34, and 17 years, respectively.

### 13.2.1 Description

The Air Stripping alternative consists of: (1) constructing the groundwater extraction system; (2) constructing a new air stripping treatment facility; (3) pumping and treating groundwater in the new facility to remove groundwater contaminants (i.e., CCL4, CHCL3, and TRCLE); and (4) discharging the treated groundwater to the Wisconsin River through a gravity discharge effluent pipe. Figures 13-2 through 13-4

show the proposed locations of the extraction system, new treatment facility, and effluent pipe for the three groundwater extraction scenarios. The alternative would be designed to meet the remedial action objectives for groundwater. The key components of the alternative are:

- site preparation and mobilization
- extraction system construction
- air stripping treatment facility construction
- gravity discharge pipe construction
- air stripping treatment facility operation
- treated groundwater discharge
- groundwater monitoring (see Subsection 13.1.1)
- institutional controls (see Subsection 13.1.1)

Groundwater monitoring and institutional controls for this alternative would be similar to that discussed in Subsection 13.1.1. The other key components are discussed in the following paragraphs.

The entire facility (i.e., extraction, treatment, and discharge) design as described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

<u>Site Preparation and Mobilization</u>. A staging area for construction materials would be established near the Tri County Farmers Co-op, just north of the intersection of County Z Road and Rt. 78. A portion of the staging area would be covered to protect equipment from inclement weather. A parking area for heavy equipment and construction-support trailers would also be located within the staging area. The staging and parking areas would be prepared by grubbing, grading, and placing gravel to a minimum depth of 1 foot.

Equipment mobilized to the site would include earth-moving equipment (e.g., backhoes, front-end loaders, and bulldozers), drill rig(s), cranes, dump trucks, and construction-support trailers.

<u>Extraction System Construction</u>. As discussed previously, three groundwater extraction scenarios were developed for the Southern Off-Post Area. Information provided in the Final RI Report (ABB-ES, 1993a) pertaining to the Southern Off-Post Area groundwater flow and contaminant distributions was used in locating extraction wells to intercept the contaminant plume. The Final RI Report (ABB-ES,

1993a) Propellant Burning Ground groundwater model, as well as the Draft Aquifer Performance Test and Groundwater Modeling Report (Woodward-Clyde, 1994a) provided by BAAP, were used for supporting information regarding aquifer characteristics, pumping rates, and extraction well zones of influence necessary to intercept the Southern Off-Post contaminant plume.

**Groundwater Extraction Scenario 1.** The purpose of this extraction scenario is to prevent further migration of the Southern Off-Post contaminant plume. Six extraction wells, identified as OPCW-1 through OPCW-6 in Figure 13-2, would be fully screened across the saturated zone with approximate screen lengths of 165 feet and approximate total depths of 230 feet bgs. These extraction wells would capture contaminated groundwater which has already migrated beyond the BAAP boundary prior to its potential discharge into the Wisconsin River. Each extraction well pump would be 10 inches in diameter and constructed of stainless steel. Grain size of the sandpack material in the annular space around the screen would be compatible with the slot size of the screen. The remaining annular space would be backfilled and sealed with bentonite. Protective casings would be installed and cemented in place. Each control well would contain a submersible pump or line-shaft turbine pump with sufficient pumping capacity to extract groundwater at the rate specified for the well (i.e., estimated to be 500 gpm per well) (Woodward-Clyde, 1994a). For purposes of the FS, the pumps are stainless steel submersible pumps. Each extraction well pump would be rated for 500 gpm at a TDH of 200 feet (40 hp) (Appendix H.1). The total groundwater flow to the treatment facility for scenario 1 would be 3,000 gpm.

The groundwater extracted from each control well would be pumped to a buried 8-inch by 12-inch SDR-17 double containment HDPE pipe constructed for transport of groundwater to a metering station (see Figure 13-2). From the metering station, an 18-inch by 24-inch SDR-17 double containment HDPE influent pipe would be constructed for transport of groundwater to the treatment facility. The influent pipe would be routed along Rt. 78, under the railroad tracks, to County Z Road.

The process of collecting groundwater via extraction wells would effectively dilute the concentrations of contaminants as detected in monitoring wells at the Southern Off-Post Area. For purposes of the FS, contaminant concentrations in groundwater pumped from the control wells were calculated based on the Final RI Report (ABB-ES, 1993a) monitoring well concentrations at the BAAP boundary, taking into consideration effective lateral and vertical dilution produced by the proposed collection wells (Appendix H.1). The boundary well contaminants and concentrations were used to approximate the worst case concentration scenario that could eventually

exist at the proposed collection wells. The groundwater contaminants originally identified in the base boundary wells are tabulated along with maximum contaminant concentrations, and contaminant concentrations approximated for the influent from the extraction wells (Table 13-4). Inorganic contaminants are not presented because there are no estimated discharge limits for inorganics. Calculations and assumptions to support these estimates are located in Appendix H.1.

Estimated surface water discharge limits are presented beside the assumed influent concentrations in Table 13-4 to show the magnitude of treatment potentially required for groundwater contaminants. The estimated surface water discharge limits assume that treatment can attain greater than 99 percent removal of groundwater contaminants (WDNR, 1990b). Since the assumed influent concentrations for all the Southern Off-Post Area contaminants are below 10 $\mu g/L$, a 99 percent reduction would bring concentrations below 0.1 $\mu g/L$ which is below most Routine Analytical Services (RAS) Method Detection Limits (MDLs).

The USEPA batch flushing model was used to estimate the Southern Off-Post Area aquifer cleanup times for Scenario 1. The model assumes there are no continuing sources of contamination, as would be effectively achieved by the BAAP boundary control wells referenced in Subsection 9.4 for the Propellant Burning Ground. The model results depend on soil bulk density, organic carbon partition coefficient of the contaminant, organic carbon fraction in the aquifer, and aquifer porosity. The organic carbon partition coefficient for TRCLE was used in the model to be conservative because it is the least mobile of the three Southern Off-Post Area organic contaminants. Maximum concentrations for CCL4 at the BAAP boundary were also used in the model to be conservative. Calculations and assumptions are contained in Appendix H.1.

For purposes of the FS, an approximate cleanup time of 61 years is used in Scenario 1 to estimate treatment facility operation and maintenance costs.

**Groundwater Extraction Scenario 2.** The purpose of this extraction scenario is to prevent further migration of the Southern Off-Post contaminant plume, and to decrease the overall cleanup time required. Twelve extraction wells identified as OPCW-1 through OPCW-12 in Figure 13-3, would be used in scenario 2. All extraction well parameters and approximations for Scenario 1 are carried through to Scenario 2. The total groundwater flow to the treatment facility would be 6,000 gpm. Table 13-5 shows the assumed influent concentrations from each of the extraction

well groups, OPCW-1 through OPCW-6, and OPCW-7 through OPCW-12. Calculations and assumptions to support these estimates are in Appendix H.1.

Estimated surface water discharge limits are presented beside the assumed influent concentrations in Table 13-5 to show the magnitude of treatment potentially required for groundwater contaminants. The estimated surface discharge limits assume that treatment can attain greater than 99 percent removal of groundwater contaminants (WDNR, 1990b). Since the assumed influent concentrations for all the Southern Off-Post Area contaminants are below 10 $\mu$g/L, a 99 percent reduction would bring concentrations below 0.1 $\mu$g/L, which is below most RAS MDLs.

The USEPA batch flushing model was run for groundwater extraction Scenario 2 for the Southern Off-Post Area. The same assumptions were made for Scenario 2 as were made in Scenario 1. Calculations and assumptions are contained in Appendix H.1. Approximate cleanup times for the two sections of the contaminant plume are as follows: BAAP boundary to well group OPCW-7 through OPCW-12 (County Z Road) requires 34 years, County Z Road to well group OPCW-1 through OPCW-6 extraction wells requires 18 years. As stated previously, the results of the batch flushing model are sensitive to the organic carbon fraction and the estimated maximum concentrations in each of the contaminant plume sections.

For the purposes of the FS, an approximate cleanup time of 34 years is used to estimate treatment facility operation and maintenance costs. However, the potential exists for shutting down well group OPCW-1 through OPCW-6 when attainment of cleanup standards is reached.

**Groundwater Extraction Scenario 3.** The purpose of this extraction scenario is to prevent further migration of the Southern Off-Post contaminant plume, and to decrease the overall cleanup time required. Twenty-four extraction wells identified as OPCW-1 through OPCW-24 in Figure 13-4, would be implemented for Scenario 3. All extraction well parameters and approximations for scenario 1 are carried through to Scenario 3. The total groundwater flow to the treatment facility would be 12,000 gpm.

Table 13-6 shows assumed inherent concentrations from each of the extraction well groups, OPCW-1 through OPCW-6, OPCW-7 through OPCW-12, OPCW-13 through OPCW-18, and OPCW-19 through OPCW-24. Calculations and assumptions to support these estimates are in Appendix I.1.

Estimated surface water discharge limits are provided beside the assumed influent concentrations in Table 13-6 to show the magnitude of treatment potentially required for groundwater contaminants. The estimated surface water discharge limits assume that treatment can attain greater than 99 percent removal of groundwater contaminants (WDNR, 1990b). Since the assumed influent concentrations for all the Southern Off-Post Area contaminants are below 10 $\mu g/L$, a 99 percent reduction would bring concentrations below 0.1 $\mu g/L$ which is below most RAS MDLs.

The USEPA batch flushing model was run for groundwater extraction Scenario 3 for the Southern Off-Post Area. The same assumptions were made for Scenario 3 as were in Scenarios 1 and 2. Calculations and assumptions are contained in Appendix H.1. Approximate cleanup times for the four sections of the contaminant plume are as follows: BAAP boundary to well group OPCW-19 through OPCW-24 requires 15 years, well group OPCW-19 through OPCW-24 to well group OPCW-7 through OPCW-12 (County Z Road) requires 17 years, County Z Road to well group OPCW-13 through OPCW-18 requires 9 years, and well group OPCW-13 through OPCW-18 to well group OPCW-1 through OPCW-6 requires 8 years. As stated previously, the results of the batch flushing model are sensitive to the organic carbon fraction in the aquifer and the estimated maximum concentrations in each of the contaminant plume sections.

For the purposes of the FS, an approximate cleanup time of 17 years is used to estimate treatment facility operation and maintenance costs. However, the potential exists for shutting down well groups when attainment of cleanup standards is reached for the corresponding aquifer section.

Air Stripping Treatment Facility Construction. A permanent groundwater treatment facility would be constructed in the vicinity of the Tri-Country Farmers' Co-op, just north of the intersection of County Z Road and Rt. 78 (see Figures 13-2 to 13-4). The building would be a pre-engineered structure installed on a reinforced concrete pad with influent and effluent equalization tanks installed below ground surface. A sump would be built into the pad to collect spilled liquids and recirculate them back into the treatment system. Electrical service would be supplied to the treatment facility for lights, HVAC, and operation of the treatment systems. The maximum electrical load in the new facility is expected to be approximately 800, 1300, and 2900 KW for Scenarios 1, 2, and 3, respectively. The nearest source that is capable of providing sufficient electricity to the treatment facility is a 12,470V three-phase power transmission line that passes along County Z Road approximately 300 feet from the proposed facility. An electrical substation incorporating a transformer and

associated switchgear would be constructed near the treatment facilities to step down the voltage for treatment system use.

Potable water would be supplied to the new facility for operation, maintenance, fire control and cleaning activities. A water supply well will be installed to the east of the facility, out of the influence of the groundwater contaminant plume.

The proposed gravity discharge effluent pipe would run from the treatment facility, along Route 78 to Dam Road and finally to the Wisconsin River (see Figures 13-2 to 13-4), a total distance of approximately 4,000 feet. The proposed discharge pipe would be made from concrete and be approximately 24 inches, 36 inches, and 48 inches in diameter for groundwater extraction Scenarios 1, 2, and 3, respectively.

Equipment installed in the new treatment facility would include self-cleaning automatic strainers, an influent equalization basin, influent transfer pumps, an air stripper system, and an effluent equalization basin. The treatment facility would change in number and sometimes size of the above-mentioned items according to the different groundwater extraction Scenarios (see Figures 13-5 to 13-7). The Woodward-Clyde 90 percent design (Woodward-Clyde, 1994b) for the on-base groundwater treatment facility was used as a reference, where appropriate, when developing the air stripping treatment facility.

One self-cleaning strainer assembly would be able to handle 3,000 gpm of flow. The strainer has an automatic backwash cycle which cleans the internal screens without being taken out of operation. The influent equalization tank would have an approximate detention time of 10 minutes, with different volumes to match each groundwater extraction scenario. Influent equalization basins of 30,000, 60,000, and 120,000 gallons would be constructed of 12-inch concrete for Scenarios 1, 2, and 3, respectively. The influent transfer pump(s) would be rated for 3,000 gpm at a TDH of 60 feet (60 HP). For design and cost purposes, a redundant pump will be included for each of the groundwater extraction scenarios. The air stripper system(s) would consist of one, two, or four 12-foot diameter strippers for Scenarios 1, 2, and 3, respectively. Each air stripper would be equipped with a 75 HP blower supplying 18,000 cubic feet per minute (cfm) at an approximate pressure of 12 inches of water, a liquid petroleum gas powered heater, and three vapor-phase carbon adsorption canisters for off-gas treatment. Engineering controls (i.e., soundproofing) would be used to mitigate noise produced by the blower(s). Calculations of the mass of groundwater contaminant emissions from air stripper(s) treating 3,000 gpm to 12,000 gpm at the influent concentrations listed in Tables 13-4 to 13-6 indicate that

the mass of CCL4 emitted from the air stripper(s) would exceed the mass allowed per Wisconsin Hazardous Air Pollutants Emissions Standards (Chapter NR 445) (i.e., approximately 132, 264, and 528 lb/year for Scenarios 1, 2, and 3, respectively, versus the 25 lb/year - CCL4 emission standard). The vapor-phase carbon adsorption canisters would eliminate contaminant emissions into the atmosphere. The effluent equalization basin would be the same size as the corresponding influent equalization basin, and made of the same material. The effluent equalization basin would be connected to the effluent discharge pipe for eventual discharge to the Wisconsin River. Approximately five manholes would be constructed between the treatment facility and the river at critical bends in the effluent discharge pipe.

Floor space required for the new treatment facility building was estimated using the following dimensions for treatment system equipment:

NOTE: Numbers of each piece of treatment system equipment can be ascertained from Figures 13-5, 13-6, and 13-7 for each groundwater extraction scenario.

- Self-Cleaning Strainer(s). Floor space required for the self-cleaning strainer assembly is estimated to be 3 by 4 feet.

- Influent and Effluent Equalization Basins. Each basin would be constructed to a depth of 10 feet and have dimensions of:

  Scenario 1: 16 feet by 36 feet (approximately 30,000 gallons)
  Scenario 2: 25 feet by 35 feet (approximately 60,000 gallons)
  Scenario 3: 35 feet by 50 feet (approximately 120,000 gallons).

- Influent Transfer Pump(s). The floor space required for one influent transfer pump is estimated to be 8 by 8 feet.

- Air Stripper(s). The floor space required for each air stripper is estimated to be 16 by 16 feet.

- Blower(s). The floor space required for each blower is estimated to be 8 feet by 8 feet.

- Liquid Petroleum Gas Powered Heater(s). The floor space required for each heater is estimated to be 12 feet by 12 feet.

- Vapor Phase Carbon Adsorption System. The floor space required for three vapor-phase carbon units in parallel is estimated to be 16 feet by 40 feet.

- Treatment facility sizes for the three groundwater extraction scenarios:

  Air Stripping - Groundwater Extraction Scenario 1. Allowing for approximately 1,300 square feet for an office/control center, and storage space, the floor space required for the building is estimated to be 6,032 square feet. For preliminary design and cost estimating purposes, the building would occupy a footprint of 52 by 116 feet.

  Air Stripping - Groundwater Extraction Scenario 2. Allowing for approximately 1,500 square feet for office/control center, and storage space, the floor space required for the building is estimated to be 9,000 square feet. For preliminary design and cost estimating purposes, the building would occupy a footprint of 75 feet by 100 feet for the treatment systems and a footprint of 30 feet by 50 feet for office/control center, and storage space.

  Air Stripping - Groundwater Extraction Scenario 3. Allowing for approximately 3,000 square feet for office/control center and storage space, the floor space required for the building is estimated to be 18,000 square feet. For preliminary design and cost estimating purposes, the building would occupy a footprint of 100 feet by 180 feet.

Air Stripping Facility Operation. New treatment facility operation would be dedicated to continuous treatment of influent from the groundwater extraction wells. The assumed contaminant concentrations in the influent from each bank of extraction wells, and the estimated surface water discharge limits are presented in Tables 13-4 through 13-6.

Operation of the new treatment facility would consist of pumping (with the extraction well pumps) contaminated groundwater through the self-cleaning strainer(s) and into the influent equalization basin. The influent transfer pump would pump water from the equalization tank to the air stripper(s) that discharge into the effluent equalization basin. Air emissions from the air stripper(s) would pass through the vapor-phase carbon units prior to discharge into the atmosphere. From the effluent

basin, the effluent would discharge by gravity through the effluent pipe to the Wisconsin River.

Removal of CCL4, CHCL3, and TRLCE would occur in the air stripper(s). Routine operation and maintenance practices would include replacement of vapor-phase carbon canisters upon CCL4 breakthrough (i.e., detectable concentrations of CCL4 in canister effluent). For the conceptual design presented here, the treatment system components would need to be shut down for a specified period of time during vapor-phase carbon canister change out.

A conservative estimate of the rate of vapor-phase carbon saturation indicates that CCL4 breakthrough would occur every 10 years of new treatment facility operation (Krauss, 1994). Consequently, approximately 3 carbon canisters would be replaced every 10 years for groundwater extraction Scenario 1. Scenarios 2 and 3 would require 6 and 12 canisters, respectively, replaced every 10 years.

During self-cleaning strainer maintenance, treatment system flow would be diverted around the strainer and allowed to enter the influent equalization basin. The groundwater influent is expected to be low in particulate matter and would have minimal to no effect on the treatment systems.

Incrustation in the form of calcium carbonate precipitation and scaling is occurring in the existing on-base IRM treatment system downstream of the air stripper (Fordham, 1992). Scaling has been so severe that it has been necessary to shut down the system to remove scale from the effluent transfer pump and process flow instrumentation. To prevent a similar occurrence from happening in the proposed off-post treatment facility, it may be necessary to feed an acidic solution into the process stream upstream of the air strippers. This would reduce pH and may prevent oversaturation of calcium carbonate in the water. Testing of the effectiveness of pH adjustment for reducing calcium carbonate precipitation would be conducted in the IRM facility prior to the Air Stripping facility construction.

For the purposes of the FS, biweekly sampling and analysis would be required to monitor performance of the treatment system. One sample would be collected from each of the three following locations: (1) the influent from each bank of extraction wells, (2) treatment system influent (for Scenario 1 this is the same as number 1), (3) from a location after each air stripper, (4) from the treatment system effluent (for Scenario 1 this is the same as number 3). Each water sample would be analyzed for groundwater contaminants as specified in Table 13-7. For the purposes of the FS,

quarterly air monitoring of the discharge from each vapor-phase carbon unit would be conducted for volatile and particulate analysis.

### 13.2.2 Cost Estimate and Sensitivity Analysis

For cost-estimating purposes, the following assumptions were made:

- air stripping treatment facility would treat an average of 3,000 gpm, 6,000 gpm, and 12,000 gpm for groundwater extraction Scenarios 1, 2, and 3, respectively.

- for O&M purposes, the air stripping treatment facility would run for 61, 34, and 17 years for groundwater extraction Scenarios 1, 2, and 3, respectively.

- each vapor-phase carbon canister would need replacement every 10 years ($18,000 per replacement) (Krauss, 1994)

- spent carbon transported off site for thermal reactivation

- each liquid petroleum gas (LPG) fired heater would consume 200 gallons LPG a day, with a cost per gallon of $0.50 per gallon (i.e., $36,500 per year)

- land required for the treatment facility, extraction wells, and piping would be obtained using easements for specified periods of time at an estimated cost of $1,200 per acre of affected land (Rushenburg, 1994)

- redundant treatment systems (i.e., additional air stripper(s)) were not addressed during the FS. If additional systems are needed, this could affect the costs considerably.

The cost estimate for this alternative for each of the three groundwater extraction scenarios is shown in Tables 13-8 through 13-10. Material usage, cost, and vendor information are provided in Appendices H.1, H.2, and H.3, respectively. Estimated remediation costs for this alternative are sensitive to a variation in the cost for carbon replacement. Off-site transport and thermal reactivation of spent carbon is heavily regulated and changes in regulations over the life of the project could result in significant increases in operating costs for this alternative. The cost of land

required for the treatment system, groundwater extraction wells and piping could increase considerably if purchase of the affected land is necessary. Pumping tests for each groundwater extraction scenario should be performed to more accurately identify extraction flows needed, as well as, influent contaminant concentrations. If the collected data differ significantly from the estimates provided in this FS, cost could be affected considerably. If acid addition is required, prior to the air stripper(s) additional costs for the acid addition system, as well as, O&M costs would need to be addressed. For groundwater extraction Scenarios 2 and 3, O&M costs may decrease significantly if cleanup standards are attained for sections of the aquifer causing subsequent shutdown of extraction well bank(s) and associated treatment systems.

### 13.2.3 Remedial Alternative Evaluation

The assessment of this alternative using the evaluation criteria is presented in Table 13-11.

## 13.3 ALTERNATIVE SOPA-GW3 CARBON ADSORPTION

This subsection describes the Carbon Adsorption alternative, provides a cost estimate and sensitivity analysis for the alternative, and evaluates the alternative using the nine evaluation criteria.

### 13.3.1 Description

The Carbon Adsorption alternative consists of: (1) constructing the groundwater extraction system; (2) constructing a new carbon adsorption treatment facility; (3) pumping and treating groundwater in the new facility to remove groundwater contaminants (i.e., CCL4, CHCL3, TRCLE); and (4) discharging the treated groundwater to the Wisconsin River through a gravity discharge effluent pipe. Figures 13-2 through 13-4 show the proposed locations of the extraction system, new treatment facility, and effluent pipe for the three groundwater extraction scenarios. This alternative would be designed to meet the remedial action objectives for groundwater. Key components of the alternative are:

- site preparation and mobilization (see Subsection 13.2.1)
- extraction system construction (see Subsection 13.2.1)
- carbon adsorption treatment facility construction

- gravity discharge effluent pipe construction (see Subsection 13.2.1)
- carbon adsorption treatment facility operation
- treated groundwater discharge (see Subsection 13.2.1)
- groundwater monitoring (see Subsection 13.1.1)
- institutional controls (see Subsection 13.1.1)

Site preparation and mobilization, extraction system construction, gravity discharge pipe construction, and treated groundwater discharge for this alternative would be similar to those discussed in Subsection 13.2.1. Groundwater monitoring, and institutional controls for this alternative would be similar to that discussed in Subsection 13.1.1. Other key components are discussed in the following paragraphs.

The entire treatment facility design as described in the following paragraphs is preliminary and was developed for remedial alternative evaluation and cost-estimating purposes.

Carbon Adsorption Treatment Facility Construction. A permanent groundwater treatment facility would be constructed in the vicinity of the Tri-County Farmers Co-op, just north of the intersection of County Z Road and Rt. 78 (see Figures 13-2 through 13-4). The building would be a pre-engineered structure installed on a reinforced concrete pad with influent and effluent equalization basins installed below ground surface. A sump would be built into the pad to collect spilled liquids and recirculate them back into the treatment system. Electrical service would be supplied to the treatment facility for lights, heating/ventilation/air conditioning (HVAC), and operation of the treatment systems. The maximum electrical load in the new facility is expected to be approximately 800, 1600, and 3000 KW for Scenarios 1, 2, and 3, respectively. The nearest source that is capable of providing sufficient electricity to the treatment facility is a 12,470V three-phase power transmission line that passes along County Z Road approximately 300 feet from the proposed facility. An electrical substation incorporating a transformer and associated switchgear would be constructed near the treatment facilities to step down the voltage for treatment system use.

Potable water would be supplied to the new facility for operation, maintenance, fire control, and cleaning activities. A water supply well would be installed to the east of the facility, out of the influence of the groundwater contaminant plume.

Equipment installed in the new treatment facility would include self-cleaning automatic strainer(s) an influent equalization basin, influent transfer pump(s), the

carbon adsorption system, and an effluent equalization basin. The treatment facility would change in number and size of the above-mentioned items according to the different groundwater extraction scenarios (see Figures 13-8 through 13-10). The Woodward-Clyde 90 percent design (Woodward-Clyde, 1994) for the on-base groundwater treatment facility was used as a reference, where appropriate, when developing the carbon adsorption treatment facility.

One self-cleaning strainer assembly would be able to handle 3,000 gpm of flow. The strainer has an automatic backwash cycle which cleans the internal screens without being taken out of operation. The influent equalization tank would have an approximate detention time of 10 minutes, with different volumes to match each groundwater extraction scenario. Influent equalization basins of 30,000, 60,000, and 120,000 gallons would be constructed of 12 inch concrete for Scenarios 1, 2, and 3, respectively. The influent transfer pump(s) would be rated for 3,000 gpm at a TDH of 60 feet (60 HP). For design and cost purposes a redundant pump will be included for each of the groundwater extraction scenarios. The effluent equalization basin would be the same size as the corresponding influent equalization basin and made of the same material. The effluent equalization basin would be connected to the effluent discharge pipe for eventual discharge to the Wisconsin River.

The influent transfer pump(s) would be rated for 3,000 gpm at a TDH of 170 feet (160 hp). The carbon adsorption system would consist of three, six, or twelve parallel trains of 2x20,000 lb. skid-mounted carbon vessels for groundwater extraction Scenarios 1, 2, and 3, respectively (see Figures 13-8 through 13-10). Each carbon vessel would have a diameter of 10 feet. The effluent equalization basin would be the same size as the corresponding influent equalization basin, and made from the same material. The effluent equalization basin would be connected to the effluent discharge pipe for eventual discharge to the Wisconsin River.

Floor space required for the new treatment facility building was estimated using the following dimensions for treatment system equipment:

NOTE: Numbers of treatment system components can be ascertained from Figures 13-8, 13-9, and 13-10 for each groundwater extraction scenario.

- Self-Cleaning Strainer(s). Floor space required for one self-cleaning strainer assembly is estimated to be 3 by 4 feet.

- Influent and Effluent equalization basing. Each basin would be constructed to a depth of 10 feet and have dimensions of:

  Scenario 1: 16 feet by 36 feet (approximately 30,000 gallons)
  Scenario 2: 25 feet by 35 feet (approximately 60,000 gallons)
  Scenario 3: 35 feet by 50 feet (approximately 120,000 gallons)

- Influent Transfer Pump(s). Floor space required for one influent transfer pump is estimated to be 8 by 8 feet.

- Carbon Adsorption System. Skid dimensions are approximately 12 by 32 feet for each 2x20,000 lb. carbon vessel skid.

- Treatment facility sizes for the three groundwater extraction scenarios:

  Carbon Adsorption - Groundwater extraction Scenario 1. Allowing for approximately 1,500 square feet for an office/control center, and storage space, the floor space required for the building is estimated to be 5,200 square feet. For preliminary design and cost estimating purposes, the building would occupy a footprint of 52 by 100 feet.

  Carbon Adsorption - Groundwater extraction Scenario 2. Allowing for approximately 2,900 square feet for an office/control center, and storage space, the floor space required for the building is estimated to be 8,640 square feet. For preliminary design and cost estimating purposes, the building would occupy a footprint of 72 by 120 feet.

  Carbon Adsorption - Groundwater extraction Scenario 3. Allowing for approximately 3,000 square feet for an office/control center, and storage space, the floor space required for the building is estimated to be 16,800 square feet. For preliminary design and cost estimating purposes, the building would occupy a footprint of 100 by 168 feet.

Carbon Adsorption Treatment Facility Operation. New treatment facility operation would be dedicated to treatment of influent from the groundwater extraction wells. The assumed contaminant concentrations in the influent from each bank of extraction wells and the estimated surface water discharge limits are presented in Tables 13-4 through 13-6.

Operation of the new treatment facility would consist of pumping (with the extraction well pumps) contaminated groundwater through the self-cleaning strainer(s) and into the influent equalization basin. The influent transfer pumps would pump water from the equalization basin through the carbon adsorption system to the effluent tank. From the effluent basin, the effluent would discharge by gravity through the effluent pipe to the Wisconsin River.

Routine operation and maintenance practices would include replacement of spent carbon in the lead carbon vessels upon CCL4 breakthrough (i.e., detectable concentrations of CCL4 in the lead vessel effluent). During carbon replacement in the lead vessels, all treatment system flow would be diverted to the polishing vessels so there is no interruption in treatment system operation. After carbon replacement in the lead vessels, the flow path through the carbon vessels would be switched by following a prescribed valve sequence so that the polishing vessel becomes the lead vessel and the lead vessel becomes the polishing vessel in the series configuration.

A conservative estimate of the rate of aqueous-phase carbon saturation indicates that CCL4 breakthrough in the lead vessel would occur twice a year (Krauss, 1994). Consequently, approximately 6 carbon rebeds would be required per year for groundwater extraction Scenario 1. Scenarios 2 and 3 would require 12 and 24 carbon rebeds, respectively, every year.

During self-cleaning strainer maintenance, treatment system flow would be diverted around the strainer and allowed to enter the influent equalization basin. The groundwater influent is expected to be low in particulate matter and would have minimal to no effect on the treatment systems during a short duration.

For the purposes of the FS, biweekly sampling and analysis would be required to monitor performance of the treatment system. One sample would be collected from each of the three following locations: (1) from the influent from each bank of extraction wells, (2) from treatment system influent (for Scenario 1 this is the same as number 1), (3) from a location after each lead carbon adsorption unit, (4) from the treatment system effluent (for Scenario 1 this is the same as number 3). Each water sample would be analyzed for groundwater contaminants as specified in Table 13-7. Table 13-7 also presents USEPA analytical methods for the contaminants.

### 13.3.2 Cost Estimate and Sensitivity Analysis

For cost-estimating purposes, the following assumptions were made:

- carbon adsorption treatment facility would treat an average of 3,000, 6,000, and 12,000 gpm for groundwater extraction Scenarios 1, 2, and 3, respectively.

- For O&M purposes, the carbon adsorption treatment facility would run for 61, 34, and 17 years for groundwater extraction Scenarios 1, 2, and 3, respectively.

- Each lead aqueous-phase carbon vessel would need replacement twice a year ($20,000 per replacement) (Krauss, 1994).

- spent carbon transported off site for thermal reactivation

- land required for the treatment facility, extraction wells, and piping would be obtained using easements for specified periods of time at an estimated cost of $1,200 per acre of affected land (Rushenburg, 1994)

- redundant treatment systems (i.e., additional carbon adsorption units) were not addressed during the FS. If additional systems are needed, this could affect the costs considerably.

The cost estimate for this alternative for each of the three groundwater extraction scenarios is shown in Tables 13-12 through 13-14. Material usage, cost, and vendor information are provided in Appendices I.1, I.2, and I.3, respectively. Estimated remediation costs for this alternative are sensitive to a variation in the cost for carbon replacement in the new facility. Off-site transport and thermal reactivation of spent carbon is heavily regulated and changes in regulations over the life of the project could result in significant increases in operating costs for this alternative. The cost of land required for the treatment system, groundwater extraction wells, and piping could increase considerably if purchase of the affected land is necessary. Pumping tests for each groundwater extraction scenario should be performed to more accurately identify extraction flows needed, as well as, influent contaminant concentrations. If the collected data differ significantly from the estimates provided in this FS, cost could be affected considerably. For groundwater extraction Scenarios 2 and 3, O&M costs may decrease significantly if cleanup standards are

attained for sections of the aquifer causing subsequent shutdown of extraction well bank(s), and associated treatment systems.

### 13.3.3 Remedial Alternative Evaluation

The assessment of this alternative using the evaluation criteria is presented in Table 13-15.

## 13.4 COMPARATIVE ANALYSIS OF ALTERNATIVES

This subsection compares the relative advantages and disadvantages of the groundwater alternatives using the evaluation criteria. A comparative summary is provided in Table 13-16.

### 13.4.1 Overall Protection of Human Health and the Environment

All of the groundwater remedial alternatives achieve remedial action objectives. SOPA-GW1 would result in continued exceedances of federal and state drinking water standards; however, institutional controls would prevent public contact with contaminated groundwater.

### 13.4.2 Compliance with ARARs

All of the groundwater remedial alternatives, except SOPA-GW1, would comply with ARARs pertinent to groundwater quality. The SOPA-GW1 (i.e., minimal action) alternative would allow the Southern Off-Post Area contaminant plume to exceed WPALs until natural attenuation and degradation processes decrease contaminant concentrations. Alternatives SOPA-GW2 and SOPA-GW3 have some exposure to changing regulations because of the volume of spent carbon that is shipped off site for thermal reactivation.

### 13.4.3 Long-term Effectiveness and Permanence

Because the source of the Southern Off-Post Area contaminant plume would be intercepted at the BAAP boundary and institutional controls would be implemented for all alternatives, minimal residual risk would result from all of the proposed alternatives.

### 13.4.4 Reduction in Toxicity, Mobility, and Volume through Treatment

Except for SOPA-GW1, each of the groundwater remedial alternatives would result in destruction of groundwater contaminants. Off-site thermal activation of spent carbon is included in both of the treatment alternatives.

### 13.4.5 Short-Term Effectiveness

No adverse impacts to the community would be experienced during implementation of any of the groundwater remedial alternatives. However, adverse impacts to the environment may be experienced during construction of the extraction system for Alternatives SOPA-GW2 and SOPA-GW3.

### 13.4.6 Implementability

No implementability concerns are associated with Alternatives SOPA-GW1, SOPA-GW2, and SOPA-GW3. It is assumed that property easements necessary to implement SOPA-GW2 and -GW3 can be easily obtained.

### 13.4.7 Cost

Alternative SOPA-GW1 has the lowest capital cost (i.e., $50,000) and the lowest present worth operation and maintenance cost (i.e., $2,889,000) compared to the other alternatives. Of the alternatives that include groundwater extraction and treatment (i.e., Alternatives SOPA-GW2 and SOPA-GW3), Alternative SOPA-GW3 has the highest total present worth capital cost, and annual operation and maintenance cost, when comparing each of the corresponding groundwater extraction scenarios to SOPA-GW2. However, the cost difference between SOPA-GW2 and SOPA-GW3 is minimal and should not be used as a decision criteria.

## 13.5 Selection of Preferred Alternative

Alternative SOPA-GW1 (i.e., Minimal Action) would achieve remedial action objectives and is the preferred alternative for the Southern Off-Post Area groundwater contaminant plume. Because future implementation of BAAP boundary control wells will allow capture of the contaminant plume originating at the Propellant Burning Ground, further contamination off-post is not foreseen. ARARs

would continue to be exceeded off-post until natural attenuation and degradation processes decrease contaminant concentrations.

The Minimal Action alternative (SOPA-GW1) relies heavily on groundwater monitoring, institutional controls and education programs to ensure that there is no potential for public exposure to the Southern Off-Post Area contaminant plume. In addition, the Off-Post Contingency Plan (ABB-ES, 1993c) outlines actions that will be taken if migration or site-related contaminants adversely affects off-post residential water. The USAEC authorized preparation of the off-post contingency plan to enable a rapid response to protect public health in the possible, though unlikely event, site-related contaminants migrate to public and private water supplies.

| | |
|---|---|
| ANAPNE | acenaphthene |
| ANAPYL | acenaphthylene |
| ACET | acetone |
| ACRYLO | acrylonitrile |
| ALK | alkalinity |
| AL | aluminum |
| NH3 | ammonia |
| NH3N2 | ammonia nitrogen |
| ANTRC | anthracene |
| SB | antimony |
| AS | arsenic |
| BA | barium |
| C6H6 | benzene |
| BAANTR | benzo(a)anthracene |
| BAPYR | benzo(a)pyrene |
| BBFANT | benzo(b)fluoranthene |
| BGHIPY | benzo(g,h,i)perylene |
| BKFANT | benzo(k)fluoranthene |
| BE | beryllium |
| B2EHP | bis(2-ethylhexyl)phthalate |
| CD | cadmium |
| CA | calcium |
| CS2 | carbon disulfide |
| CCL4 | carbon tetrachloride |
| CL | chloride |
| CHCL3 | chloroform |
| CR | chromium |
| CHRY | chrysene |
| CO | cobalt |
| CU | copper |
| DBAHA | dibenzo(a,h)anthracene |
| DBZFUR | dibenzofuran |
| DEETH | diethyl ether |
| DEP | diethylphthalate |
| DNBP | di-n-butyl phthalate |
| DNOP | di-n-octyl phthalate |

| | |
|---|---|
| DPA | diphenylamine |
| ETC6H5 | ethylbenzene |
| FANT | fluoranthene |
| FLRENE | fluorene |
| HARD | total hardness |
| ICDPYR | indeno(1,2,3-cd)pyrene |
| FE | iron |
| PB | lead |
| MG | magnesium |
| MN | manganese |
| HG | mercury |
| CH2CL2 | methylene chloride |
| MEK | methyl ethyl ketone or 2-butanone |
| NAP | naphthalene |
| NI | nickel |
| NO3 | nitrate |
| NO2 | nitrite |
| NIT | nitrite/nitrate-nonspecific |
| NB | nitrobenzene |
| NC | nitrocellulose |
| N2KJEL | nitrogen by Kjeldahl Method |
| NG | nitroglycerine |
| NNDMEA | n-nitrosodimethylamine |
| NNDNPA | n-nitrosodi-n-propylamine |
| NNDPA | n-nitrosodiphenylamine |
| PHANTR | phenanthrene |
| K | potassium |
| PYR | pyrene |
| SE | selenium |
| AG | silver |

| | |
|---|---|
| NA | sodium |
| SO4 | sulfate |
| | |
| TDS | total dissolved solids |
| TL | thallium |
| TRIMBZ | trimethylbenzenes |
| SN | tin |
| MEC6H5 | toluene |
| HARD | total hardness |
| TDS | total dissolved solids |
| TRCLE | trichloroethylene |
| | |
| V | vanadium |
| C2H3CL | vinyl chloride |
| | |
| BTEX | xylenes |
| XYLEN | xylene |
| TXYLEN | xylenes, total combined |
| | |
| ZN | zinc |
| | |
| 11DCLE | 1,1-dichloroethane |
| 11DCE | 1,1-dichloroethylene |
| 111TCE | 1,1,1-trichloroethane |
| 112TCE | 1,1,2-trichloroethane |
| 12DCLE | 1,2-dichloroethane |
| 12DCE | 1,2-dichloroethylene |
| 123PDA | 1,2,3-propadetriol diacetate |
| 13DMB | 1,3-dimethylbenzene |
| MEK | 2-butanone or methyl ethyl ketone |
| 2MNAP | 2-methylnaphthalene |
| 2NANIL | 2-nitroaniline |
| 2NNDPA | 2-nitro-n-nitrosodiphenylamine |
| 236TMN | 2,3,6-trimethylnaphthalene |
| 24DNT | 2,4-dinitrotoluene |
| 26DNT | 2,6-dinitrotoluene |
| 3NT | 3-nitrotoluene |
| 3NANIL | 3-nitroaniline |
| 4NANIL | 4-nitroaniline |

## GLOSSARY OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ART | Alternative Remedial Technologies |
| ABB-ES | ABB Environmental Services, Inc. |
| AEC | U.S. Army Environmental Center |
| AMC COM | Armament Munitions and Chemical Command |
| ARAR | Applicable or Relevant and Appropriate Requirement |
| AWQC | Ambient Water Quality Criteria |
| BAAP | Badger Army Ammunition Plant |
| bgs | below ground surface |
| CAA | Clean Air Act |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CLASS | Contract Laboratory Analytical Services Support |
| CMS | Corrective Measures Study |
| cm/sec | centimeters per second |
| COC | chemicals of concern |
| CPAH | carcinogenic polynuclear aromatic hydrocarbons |
| CSF | Carcinogen Slope Factor |
| CWA | Clean Water Act |
| cfm | cubic feet per minute |
| DDT | dichlorodiphenyltrichloroethane |
| DNT | dinitrotoluene |
| ECOC | ecological chemicals of concern |
| EEI | Envirodyne Engineers, Inc. |
| EP | extraction procedure |
| EPTOX TV | extraction procedure toxicity threshold value |
| ES | enforcement standards |
| $f_{oc}$ | fraction of organic carbon |
| FS | Feasibility Study |
| ft/ft | feet per foot |
| ft/yr | feet per year |
| FUDS | Formerly Used Defense Sites |
| gpd | gallons per day |
| gpm | gallons per minute |

| | |
|---|---|
| HAs | Health Advisories |
| HCOC | human health chemicals of concern |
| HI | Hazard Index |
| hp | horsepower |
| HQ | Hazard Quotient |
| HSWA | Hazardous and Solid Waste Amendments |
| HVAC | heating/ventilation/air conditioning |
| IGT | Institute of Gas Technology |
| IRM | interim remedial measure |
| kg | kilogram |
| $K_{ow}$ | octanol-water partition coefficient |
| KVA | kilovolt amp |
| KW | kilowatt |
| $M^3$ | cubic meter |
| MCL | Maximum Contaminant Level |
| MCLG | Maximum Contaminant Level Goal |
| MEC | Millgard Environmental Corporation |
| MEP | Master Environmental Plan |
| mg | milligram |
| mg/kg | milligrams per kilogram |
| mg/kg-day | milligrams per kilogram per day |
| mg/L | milligrams per liter |
| $mg/m^3$ | milligrams per cubic meter |
| MSL | mean sea level |
| MVA | megavolt amp |
| NAAQS | National Ambient Air Quality Standards |
| NAM | nitrosamine |
| NCP | National Oil and Hazardous Substances Contingency Plan |
| NEPA | National Environmental Policy Act |
| NESHAP | National Emission Standards for Hazardous Air Pollutants |
| NG/RPA | Nitroglycerine Pond and Rocket Paste Area |
| NPL | National Priorities List |
| NSPS | New Source Performance Standards |
| OCP | Off-Post Contingency Plan |

## GLOSSARY OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| OLM | organic leaching model |
| OSHA | Occupational Safety and Health Administration |
| | |
| PALs | Preventive Action Limits |
| PCB | polychlorinated biphenyls |
| POTW | Publicly Owned Treatment Works |
| ppm | parts per million |
| PRG | preliminary remediation goal |
| PSD | Prevention of Significant Deterioration |
| | |
| QA/QC | quality assurance/quality control |
| | |
| RCRA | Resource Conservation and Recovery Act |
| RfC | reference concentration |
| RfD | reference dose |
| RFI | RCRA Facility Investigation |
| RG | remediation goal |
| RI | Remedial Investigation |
| RTV | reference toxicity value |
| | |
| SARA | Superfund Amendments and Reauthorization Act |
| scfm | standard cubic feet per minute |
| SDWA | Safe Drinking Water Act |
| SIP | State Implementation Plan |
| S/S | Stabilization/Solidification |
| SSP | Spoils Disposal Area |
| SVOC | semivolatile organic compound |
| SWMU | Solid Waste Management Unit |
| | |
| TBC | to be considered |
| TBD | total body dose |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TDH | total dynamic head |
| TSD | treatment, storage, or disposal |
| | |
| USAEC | U.S. Army Environmental Center |
| USAEHA | U.S. Army Environmental Hygiene Agency |
| USAMC | U.S. Army Material Command |
| USATHAMA | U.S. Army Toxic and Hazardous Materials Agency |

| | |
|---|---|
| USEPA | U.S. Environmental Protection Agency |
| UV | ultraviolet |
| VOC | volatile organic compound |
| WAC | Wisconsin Administrative Code |
| WDNR | Wisconsin Department of Natural Resources |
| WES | Wisconsin Enforcement Standard |
| WPAL | Wisconsin Preventive Action Limit |
| WP&L | Wisconsin Power and Light |
| WPDES | Wisconsin Pollutant Discharge Elimination System |
| WWTP | wastewater treatment plant |
| $\mu g/g$ | micrograms per gram |
| $\mu g/L$ | micrograms per liter |
| $\mu g/m^3$ | micrograms per cubic meter |

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